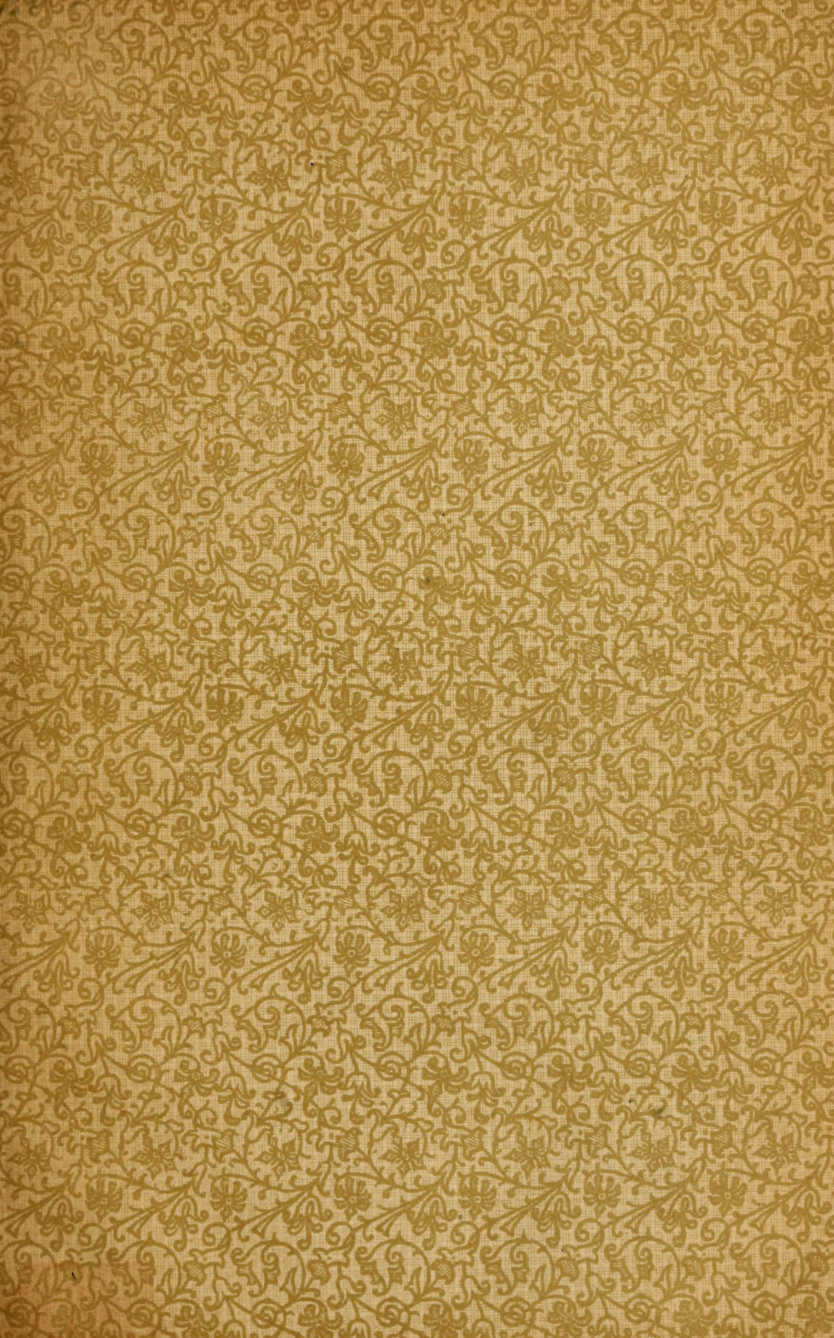


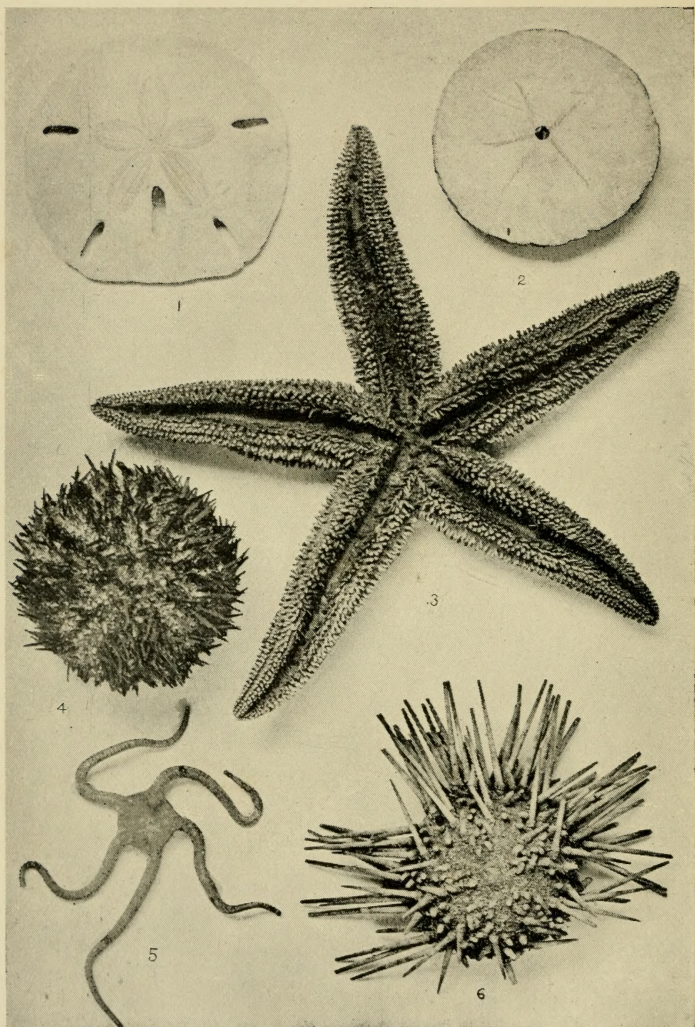
THE
ANIMAL LIFE
OF OUR
SEA-SHORE



CARD 1040

G. ESTECHER & CO.
(ALFRED HAFNER)
NEW YORK





(PLATE 5.)

1. Mellita.

2. Echinarachnius.

3. Asterias.

4. Strongylocentrotus.

5. Ophiura.

6. Arbacia.

March 1894
Purchased
of the
Museum
of
Natural
History
of
Philadelphia
127
H46X
INV 2

THE
ANIMAL LIFE
OF OUR
SEA-SHORE.

WITH SPECIAL REFERENCE TO THE NEW JERSEY
COAST AND THE SOUTHERN SHORE
OF LONG ISLAND.

BY

ANGELO HEILPRIN,

Professor of Invertebrate Paleontology at, and Curator-in-Charge of, the Academy
of Natural Sciences of Philadelphia; Professor of Geology at the
Wagner Free Institute of Science, Philadelphia.

AUTHOR OF

"Town Geology: The Lesson of the Philadelphia Rocks," "The Geographical
and Geological Distribution of Animals," "The Geological
Evidences of Evolution," etc.

GEO. R. BRUSH, M. D.
U. S. NAVY.
Sayville, L. I., N. York.

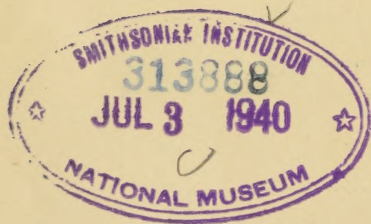
PHILADELPHIA:

J. B. LIPPINCOTT COMPANY.

1888.

INVERTEBRATE
ZOOLOGY
Crustacea

Copyright, 1888, by ANGELO HEILPRIN.



LIBRARY
DIVISION OF CRUSTACEA

591.92
H45
\$ Mar. inv.
Crust

PREFACE.

IN my official capacity as Curator of the Academy of Natural Sciences I have been frequently requested to prepare a small hand-book on the local fauna of Philadelphia and on the animal life of the much-frequented New Jersey coast. For a long time I hesitated, knowing what difficulties the preparation of a work intended to meet the requirements of the popular mind and of the more earnest searcher after nature's truths would entail. But finally, yielding to the imputation that scientists, while asking much for themselves, are too apt to disregard the claims of the scientifically-inclined public, I consented in part, and now present to my readers the following pages as a result of my determination to assist in the cause of popular instruction. For a work on the sea-shore fauna there has, doubtless, been considerable demand, and I can but hope that the present volume may in a measure fulfil the mission for which it is intended.

The illustrations that accompany the text are in

part original, but in the main they are culled from the works of DeKay, Gould, Morse, A. Agassiz, Tryon, Smith, Verrill, and Emerton, to whom, consequently, I am placed under obligation. To the last-named gentleman, author of a handy little volume designed for the New England coast, "Life on the Sea-Shore," do I particularly wish to express my acknowledgment. The student who desires to enter somewhat more fully into the study of our sea-shore fauna than is possible from the following pages will do well to consult Dr. Leidy's paper, "Contributions towards a Knowledge of the Marine Invertebrate Fauna of the Coasts of Rhode Island and New Jersey" (published in the *Journal of the Academy of Natural Sciences of Philadelphia*, vol. iii.), and Prof. Verrill's report on the "Invertebrate Animals of Vineyard Sound," prepared for the United States Commission of Fish and Fisheries (1873).

ANGELO HEILPRIN.

ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA,

June 18, 1888.

CONTENTS.

	PAGE
I.—THE SHELL-FISH OF THE COAST	7
II.—SQUIRTS, POLYPS, AND JELLY-FISHES	54
III.—STAR-FISHES, SEA-URCHINS, AND SEA-CUCUMBERS	73
IV.—OUR CARCINOLOGICAL FRIENDS	81
V.—WORMS, MOSS-POLYPS, SPONGES, ETC	108
VI.—SOME COASTWISE FISHES	120

THE ANIMAL LIFE OF OUR SEA-SHORE.

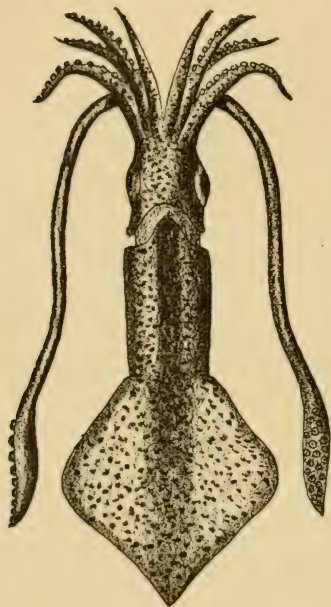
I.

THE SHELL-FISH OF THE COAST.

ALTHOUGH it can scarcely be said that the New Jersey shores constitute favorite haunts of the molluscous animals, yet interesting forms of one kind or another can at almost all times be found. Apart from the commoner species that are habitually met with on the sands, the 'harvester of the seas' who follows in the track of recent high-water, or gleans the product of a stiff south-easter, is almost sure to meet at this time with some of the rarer specimens, which are generally strangers to the visitors to the shores. Among these may possibly be a cuttle-fish, whose body has been haplessly cast upon the sands, and left by the retreating waters as a food-offering to the gulls and other sea-birds that frequent the region.

The cuttle-fishes of the New Jersey coast are not numerous, and they are rarely met with along the sands, except under the special circumstances that have just been indicated. In the deeper and quieter waters of the numerous inlets, especially around the mouths of outflowing streams, where the chances of stranding are less imminent, they are not exactly uncommon, and have even been scooped up by means of the landing-net. The

common form, and the one that is almost alone met with, is the squid or calamary,—the *Loligo Pealii* of naturalists,—an animal measuring some 9 inches in the length of its body, or 18 inches



LOLIGO PEALII.

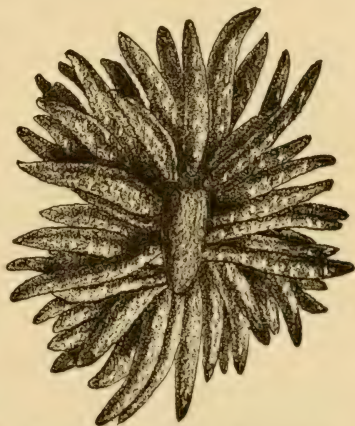
including the length of its longest arms. None of the fabulous monsters that have wrung from the poet and the novelist their mythical conceptions of the 'devil-fish,' or anything that at all approaches in dimensions the famous 20-foot specimen formerly preserved in the New York Aquarium, has ever been noted from this part of the Atlantic coast. But whether large or small our animal is alike interesting. The beauti-

ful tints of the body, which, chameleon-like, vary as different patches of pigment-particles are exposed to the surface, cannot fail to elicit admiration, even though the general appearance of the creature prove at first a trifle repulsive. There are, however, a number of interesting points about this animal which stamp it at once as being no ordinary specimen.

In the first place, a cuttle-fish, of whatever form

it may be, is next to the backboned or vertebrate animals—the fishes, reptiles, birds, and quadrupeds—about the most complex, or, if you choose, most highly organized, of the entire animal series. It takes precedence over the star-fish, insect, crab, and lobster, and, among its own class, over the snail, clam, and oyster. It alone among the thousands—nay, hundreds of thousands—of invertebrate animals, or those lacking a backbone, possesses a distinct covering or capsule to its principal nerve-mass, the brain, thus foreshadowing the structure which is so distinctive a feature of all the higher animals. The skull

of the cuttle-fish has not yet, however, been converted into bone, but remains in a cartilaginous condition, recalling in great measure the condition of the skull in some of the lower fishes, the sharks and rays and sturgeon, for example. Again, we note a special development



EGG-CASES OF *LOLIGO* ('SEA-GRAPE').

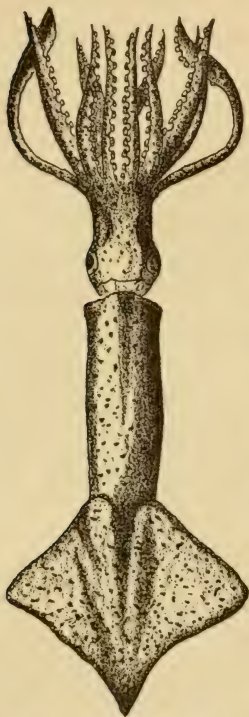
of the sense organs. The great round eyes that are situated on either side of the head have a perfection but little inferior to that of the eyes of the highest animals, and are provided, although in a somewhat different order of arrangement, with the

various tunics and bodies which belong to the most perfectly constituted eye.

Should you have succeeded in catching or finding a squid, then follow me in the examination of its parts. Observe the ten arms (or more properly feet, as it is by means of these that the animal walks or creeps about, head downward), two longer (tentacles) than the remaining eight, and the peculiar cup-like bodies with which they are furnished at their extremities. These so-called 'acetabula' are in reality organs of adhesion, each one acting on the vacuum process which is familiar to all boys who have experimented in brick-lifting with the leather 'sucker' and string. The animal can, therefore, not only entwine its arms about the object of its special search, but can stick to it by means of its sucking disks. Look between the arms, and at their base you will observe the mouth; gently separate the mouth, and you will bring to light a pair of remarkable jaws or beaks, almost exactly like those of a parrot, only reversed,—*i.e.*, the larger beak is below, and the small one above. On one side of the animal—which would be the rear, if the creature were held head downward—you will observe in the gill-cavity, which is enclosed in a lap of the body-mantle, the peculiar tubular organ known to naturalists as the 'funnel.' Through this funnel much of the water that is contained in the gill-cavity, and is used in the aëration of the blood, is periodically passed out by the animal. The stream of ejected water, reacting upon the surrounding medium, causes a rebound in the animal, the extent of which

will naturally depend upon the force and quantity of the water ejected. This retrograde motion appears to be the more general form of movement of the animal at such times when it is not actually creeping about, head downward, along the oceanic floor, although through a twisting of the funnel, or even by means of the fin attached to the hinder part of the body alone, the animal is enabled to pursue a forward course as well. The funnel also serves as an exit to that very remarkable ink-like substance, known as sepia, or true India ink, which is secreted by a special glandular body (ink-bag) lodged in the body-substance. Most of the cuttle-fishes are provided with this inky material, which, indeed, constitutes their principal weapon of defence. Instead of boldly sallying forth to meet their would-be assailants, wisdom has guided these animals to avoid their more powerful opponents, which they do by clouding the waters with a heavy discharge of sepia. Under cover of the darkness thus produced they generally manage to escape. The effect of the sepia-discharge not only suffices to discourage the enemy, but frequently from its copiousness proves deadly to it. I well remember my first dredging exploits in the Bay of Naples, when, flushed with the excitement attending a rare capture, I unguardedly dropped a cuttle-fish into a tub containing my choicest specimens from the deep. In an instant the vision of sea-horses, star-fishes, sea-anemones, etc., faded off into a cloud of increasing blackness, through which no beam of life again penetrated to the surface.

A form of squid very similar to the one just described, and largely replacing it in the northern



OMMASTREPHESES SAGITTATUS.

waters, is the *Ommastrephes sagittatus*, in which the tentacular arms are of comparatively short length, and the cornea of the eye perforated, so as to permit of the entry of sea-water to the lens.

While rare with us, this animal sometimes appears in the northern waters in immense shoals, following in the wake of the mackerel, which constitutes its selected food. In this condition it does not hesitate to enter the pounds and weirs, or to navigate between the piles of wharves, darting with the swiftness of an arrow into the midst of its prey, and pouncing upon the neck of a selected victim. In this

pursuit of the mackerel the squid may be observed to change color frequently, adapting itself in tone, by an intuitive manipulation of the pigment-bodies (chromatophores), to the surroundings which it traverses. The squid, like many other cuttle-fishes, is in a measure nocturnal in its habits, and is thought to be fond of gazing at the moon.

This habit appears to account for the numbers frequently found stranded at the time of full moon, the animal, while gazing at the luminary, incautiously

swimming backward and befouling itself on the sands.



SEPIOLA ATLANTICA.

A word or two about the cuttle-bone. We frequently hear of this substance in connection with the keeping of canary-birds, but probably there are not many who associate it with a creature at all resembling our squid.



PEN OF
SQUID.

If we slice open the back of our animal, or that side which lies opposite to the funnel, we observe embedded within the flesh a long, horny style, which is usually designated the 'gladius' or pen. It may be said to constitute a sort of internal skeleton, giving a certain amount of rigidity to the body; but its exact functions are not known. In some of the cuttle-fishes, notably those which have received the name of sepia, the gladius is replaced by a limy plate, which is in reality the cuttle-'bone' of the canary-bird cage.

It may be your good fortune in walking along the beach to stumble upon a very beautiful and

delicate coiled shell, looking somewhat like that of an ordinary snail, but differing in that the coil is open, and that it is distinctly chambered, besides



SHELL OF
SPIRULA.

having a pearly lining. This is the shell of another member of the cuttle-fish group, known to fame as the Spirula. Myriads of these shells are sometimes found about favored coast-lines, but, singular though it may appear, the sight of the living animal is one of nature's rarities. The record of observed specimens

thus far indicates less than a dozen individuals. Accordingly, we know but little of the habits of the animal inhabiting the shell, and equally little of its

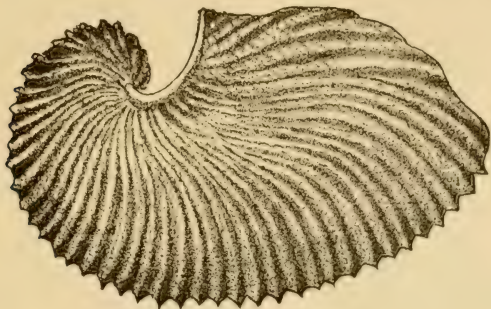


SHELL OF PEARLY NAUTILUS.

distribution. This holds also true of the 'Pearly Nautilus,' a not very distant ally of the Spirula, whose beautiful shells are offered for sale at nearly all the marts along the sea-shore, and are even thought by many to have been gathered in the vicinity. But the home of the Nautilus is a distant one, and its cradle not improbably the deep-sea.

Chance has on more than one occasion brought to our shores a rare specimen in the shell of the 'Paper Nautilus,' or Argonaut, that singular creature whose Ulyssean journeys were supposed to

have been performed under full sail. The broadly-expanded, uplifted arms, which are seen on many of the older illustrations, and which were supposed to catch the gentle zephyrs of the purple sea, are now known to be closely appressed to the side of



SHELL OF ARGONAUT.

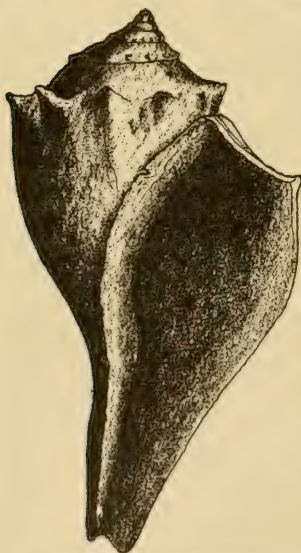
the shell, which they in truth secrete. Far, therefore, from presenting the graceful outlines to which we have been accustomed, the Argonaut in swimming much more nearly calls forth the image of a retreating sneak. But the shell, considered apart from the animal, is perhaps the most beautiful and delicate that has been fashioned by nature. Owing to its great frailness it is but rarely found uninjured, the free margins usually exhibiting nicks and cracks of greater or less extent. Hence the value attached to perfect specimens. For one such specimen of unusual size, formerly in the possession of the Boston Society of Natural History, it is claimed that the purchase-money amounted to \$500. The shell belongs exclusively to the female, and its

sole purpose appears to be the protection of the eggs which are deposited within it.

A live Argonaut was captured at Long Branch in August, 1876, and its habits in confinement watched for a period of some eight or nine days. When not swimming, the animal frequently reverses its position, crawling about with its shell on its back in the manner of a snail; at other times, again, it is said to paddle about much like an oarsman.

MARINE SNAILS.

The ocean has retreated, and upon the broad



PEAR-CONCH (*Fulgur carica*).

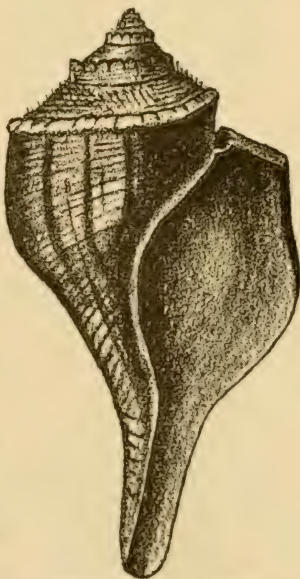
strand that shelves gradually to the still breaking crest, myriads of shells and shell-fragments lie scattered about in curling zigzags. Among these we recognize the spiral shell of the snail, and the half-shell of the clam and its allies; more rarely, both valves of the latter are found, still firmly united by the binding ligament. Some of these contain the living animal, but by far the greater number have been robbed of their possessors by the

billows that consigned them to futurity.

Of the snails the form that is most apt to at-

tract immediate attention is the pear-conch, which is about the largest shell of the coast,—indeed, one of the largest shells of the entire North American coast. Not uncommonly the animal is found within the shell, where, it will be observed, it has closely withdrawn itself, partially closing up the aperture by means of a horny disk attached to its foot, known as the ‘operculum.’ Thus shut up in its house the animal is fairly secure from its enemies, and, if sufficiently fortunate to regain the incoming waters, may again rejoice in its favorite haunts. But too long exposure to the dry atmosphere will prove fatal to it, as it likewise would to the greater number of marine snails.

The pear-conch, of which we recognize two species, one furnished with tubercles on the angles of its whorls (*Fulgur carica*), and the other practically devoid of tubercles, and showing a canallicule running around the tops of the whorls (*F. canaliculatus*), inhabits the tidal zone, where it buries itself to the depth of a few inches in the sand. Its presence can frequently be detected by hollows in the sand, into which it has introduced itself by bur-

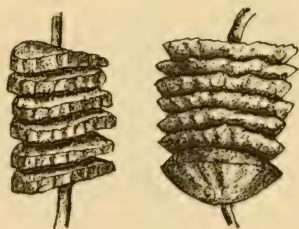


FULGUR CANALICULATUS.

rowing. There are probably few visitors to the beach who have not observed and pondered over the coiled strings of parchment-like capsules which here and there dot the shore. They have been likened by some to the rattlesnake rattle, by others they are loosely spoken of as 'sea-weeds,' under which designation many a helpless animal form has been compelled to fall. The capsules on the string are in reality the egg-cases of the pear-conch, and in order to satisfy yourself on this point slice open one such, and note the number of embryo conchs that it contains. In the dry capsules probably only the minute shells will be found, but in the ribbons that appear fresh and elastic the tiny embryos present themselves in full activity. It will be observed that toward one end of the ribbon the capsules become smaller and smaller, and more distantly removed from one another, while toward the opposite end they become larger and more crowded. The attenuated end, if entire, will almost invariably be found to terminate in a pebble or shell-fragment, to which, as to an anchor, it has been secured by the animal immediately after extrusion, and for the purpose of obtaining a firm base of attachment. It may appear remarkable that such a large ribbon should ever have been contained within a single body, for really if wound up it would form a mass even larger than the entire animal. It can only be supposed that the capsules are a long time in making, appearing gradually one after the other during a considerable period of ribbon-manufacture and extrusion. They,

doubtless, also to a certain extent become swelled up by the water which they must necessarily imbibe.

The exact period of spawning of these pear-conchs upon our coast has not yet been definitely ascertained, but from the frequency with which the fresh ribbons are found, it is not unlikely that the spawning-season extends over a considerable part of the year. So secretly and quietly does the conch attend to its affairs, that it is only at the widest intervals that it has been observed in the process of spawning; indeed, it is well known that there are but few naturalists who have observed it in this condition. There are two kinds of ribbons found



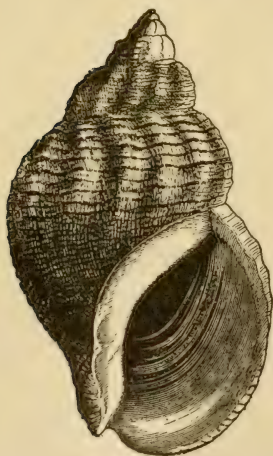
1
EGG-CAPSULES OF 1, *FULGUR CARICA*;
OF 2, *F. CANALICULATA*.

on the beach,—one in which the individual capsules have a sharp median edge, and the other in which the capsules are doubly carinated or keeled, appearing like a wheel with a double flange. The former belongs to *Fulgur canaliculata*, and the latter to *Fulgur carica*. Each capsule—of which there may be some 75 or 100 on a single ribbon—shows a round opening at about the middle of its outer border, through which the embryo conchs make their escape.

A word may not be amiss here with regard to the blue or blackish specimens that you have collected. The suspicion has for some time existed

that these dark-stained conchs, and other shells of a like character, have been washed out of a submarine deposit, or from some clay-bank containing fossil remains. That there is some reason for considering all such as fossils is indicated in the fact that, on and off, specimens not now known to inhabit the New Jersey coast are thrown upon the beach, some of which have been recognized as fossils elsewhere. But for the present it is not safe to accept the hypothesis for an established fact, especially as a number of the more brightly-colored shells, such as the scallops, have at least in part the distinctive deep-blue tinge.

Among the rarer shells of the coast is the whelk (*Buccinum undatum*), whose habitat is more prop-



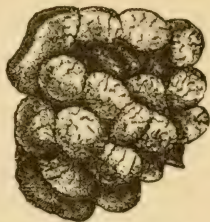
WHELK.

erly the region lying north of Cape Cod peninsula, extending thence eastward to the European continent. With us it is generally found in a largely dilapidated condition, indicating considerable wear, and a not improbably distant home. It inhabits a zone extending from low water very nearly to the greatest depths, where it plies its trade as one of the most voracious of the marine snails. Great numbers of the whelk are

caught (more especially on the north European

coast, where it is extensively used as an article of food, and as fish-bait) by dropping dead cod in a wicker-basket to a muddy bottom, where the animals are easily attracted. The whelk-fishery of Whitstable flat, England, is said to have yielded £12,000 yearly immediately prior to 1866.

The whelk is a favorite article of food with many fishes, particularly the cod, and as many as 30 and 40 of its shells have been taken from the stomach of a single fish. Eventually these shells may become the habitations of one of the numerous species of hermit crab. Indeed, on the New England coast it is rather a rarity to meet with a fresh shell of the *Buccinum* which is not already tenanted by a hermit.



EGG-CAPSULES OF WHELK.

Cast your eyes for a moment from the glistening sands towards the mud-flats and tide-pools which have been left by the retreating waters. Here, in these quieter realms, you are almost sure to meet with a number of interesting molluscan forms, among which are two or three near cousins of the whelk. They are small snails, whose shells barely measure three-quarters of an inch in length. They are figured on Plate 1, Figs. 5, 11, 6, and are known as dog-whelks (*Nassa trivittata*, *Nassa vibex*, and *Nassa obsoleta*). It will be seen that, while the shells differ considerably from those of the true whelk, they still have much the same general character, especially noticeable in the form of the aper-

ture, and its direct truncature; but the base of the inner side of the aperture shows more or less of a fold, which is wanting in the whelk. These active creatures of the tide-water pools, whose long and slender foot constitutes so marked a feature of their anatomy, offer an interesting study to the loungee on the sands, and even if their habitat is a little moist a pair of rubbers will readily bring you to them without discomfort. Observe them gliding along the surface of the mud, furrowing the soft bottom with their extended foot. A few, possibly, are floating, with the foot directed upwards. The dog-whelk is decidedly predaceous in its habits, boring rapidly through the shells of other mollusks in quest of animal food, and creating general havoc in its neighborhood. Indeed, it feeds not only upon live flesh but upon dead flesh as well, acting the part of a scavenger. Hence the use to which this little creature has been put to clean out the foul animal matter from aquaria. Its own shell appears frequently pierced with a hole, and rumor points towards cannibalism on the part of the animal. One of the foreign dog-whelks (*Nassa reticulata*) is known to prove exceedingly destructive to the oyster-farms of the French coast, and so numerous is it that a single tide has yielded upwards of 14,000 specimens on a shore area of about 100 acres. This species has been known to bore through the shell of a three-year oyster within eight hours, and to destroy an oyster of a single month in a half-hour.

A large proportion of the dog-whelk shells of our

PLATE 1.

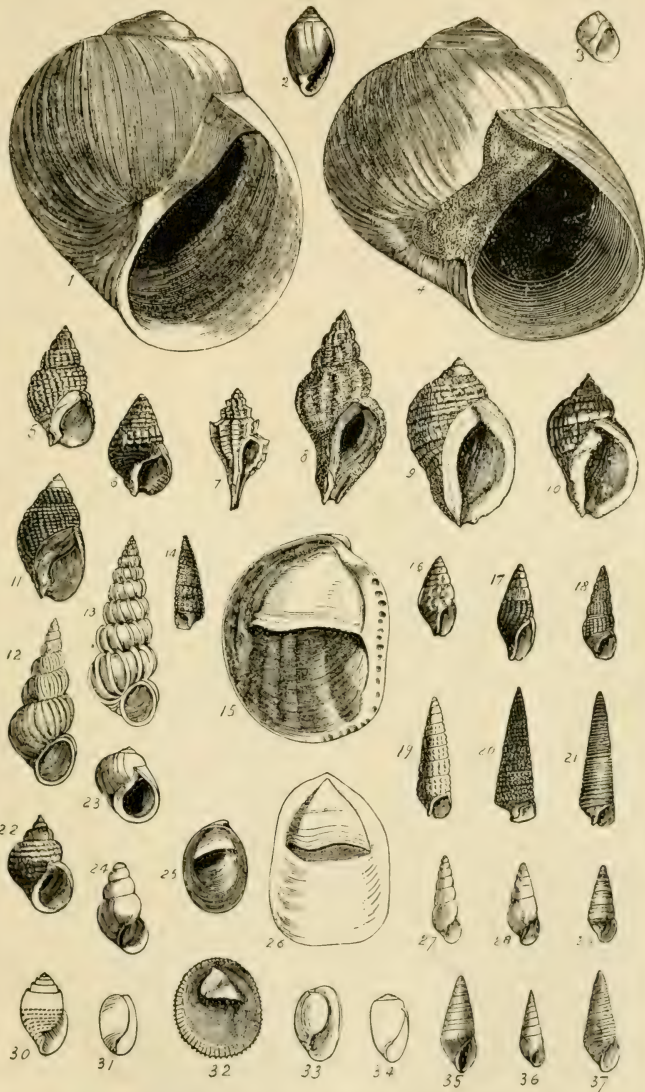
FIG.

1. *Natica heros*.
2. *Melampus bidentatus*.
3. *Natica pusilla*.
4. " *duplicata*.
5. *Nassa trivittata*.
6. " *vibex*.
7. *Eupleura caudata*.
8. *Urosalpinx cinerea*.
- 9, 10. *Purpura lapillus*.
11. *Nassa obsoleta*.
12. *Scalaria multistriata*.
13. " *lineata*.
14. *Triforis nigrocinctus*.
15. *Crepidula fornicata*.
16. *Columbella lunata* ($\times 2$).
17. " *avara*.
18. *Turbonilla elegans* ($\times 2$).
19. *Cerithiopsis Greenii* ($\times 4$).
20. " *Emersonii* ($\times 1\frac{1}{2}$).

FIG.

21. *Cerithiopsis terebralis* ($\times 1\frac{1}{2}$).
22. *Littorina rudis*.
23. " *palliat*.
24. *Littorinella minuta* ($\times 2$).
25. *Crepidula convexa*.
26. " *plana*.
27. *Odostomia producta*.
28. " *fusca* ($\times 3$).
29. " *trifida*.
30. *Actæon puncto-striata* ($\times 3$).
31. *Cylichna oryza* ($\times 2$).
32. *Crucibulum striatum*.
33. *Bulla solitaria*.
34. *Utriculus canaliculatus*.
35. *Odostomia trifida*.
36. *Eulima oleacea*.
37. *Odostomia impressa* ($\times 2$).

. The representation $\times 2$, etc., indicates that the figure has been enlarged to two linear dimensions.



coast are inhabited by hermit crabs, which in many cases, possibly, obtained possession through the right of force of arms. Be this as it may, it is certain that the hermit has been providentially provided for, and that it has much to offer by way of gratitude to the dog-whelks. The Nassas are probably all very tenacious of life; a specimen of *Nassa obsoleta* submitted to me from Atlantic City survived for a full year the dry atmosphere of a closet with an artificially-heated wall.

The Nassas are not the only inhabitants of the tide-pools either, for with them we find associated one or more forms of periwinkles, various small fishes, and the ever-active hermit. Other organisms, whose existence would scarcely have been thought of, also lurk here. One of these is the founder of a colony which has settled on the back of old *Nassa obsoleta*, and there spread out a crisp brown covering, much resembling dry moss, which might be readily mistaken for the horny covering (epidermis) which belongs to most shells. The colony is one of polyps, next of kin to the Sertularia or sea-fir, whose delicate bunchy masses lie scattered over the beach, or gently oscillate in the calmer waters of favored localities. Indeed, our polyp is a nearly of the common fresh-water hydra, and, what may at first sight appear incredible, also of the free-swimming Medusa or jelly-fish. Under a magnifier the brown covering is seen to rise up into simple and compound spines, from between



POLYP COLONY
OF HYDRACTI-
NIA ECHINATA.

which, in the living condition of the organism, the tiny white polyps, with their circle of tentacles, may be seen to rise to a height of perhaps a quarter inch or so. Between these tentacular polyps again, which are strictly those elements of the compound organism which secure nutrition to the colony at large, may be found at times a number of smaller bodies, without tentacles, which give origin to, and carry, the egg-capsules, in each of which there are from one to five eggs. Thus does this diminutive colony live in concert, different parts administering to the different wants of the assembled multitude. Most of the crusts of the *Hydractinia echinata*, for so the polyp is called, are found on the hermit-inhabited shells, but naturally where these have been exposed for too long a time to the dry atmosphere only the crust remains.

Along with the dog-whelks, we find many of the tide-water pools inhabited by a number of small round-mouthed shells, known as periwinkles or



PERIWINKLE (*Littorina irrorata*).

Littorinas, a northern species of which (*Littorina litorea*), inhabiting both the American and European coasts, is the common periwinkle of the English markets. These interesting creatures, of which there are three species* on the New Jersey coast, are truly marine in habit, but still prefer for their habitations localities that are only partially

* Since the above was written *Littorina litorea* has been found at Atlantic City; it is a much less elevated shell than the common large periwinkle of our coast (*L. irrorata*).

covered by the sea. We find them clinging to rocks, to old wharf-piers and other immersed timber, to sea-weeds and the grass-culms of marshes, as well as enjoying the more placid retreats afforded by the sluggish waters of the tide-water marshes, pools, and ditches. The positions selected by them, usually just within the reach of high-water, would seem to indicate a positive aversion on the part of the animal to the full waters of the sea, and they appear rarely to venture into the embrace of the surf. One species of our coast (*Littorina rudis*) has been known to live a week out of water, while another, from the West Indies, survived similar deprivation for a full year; a species from the North European coast, again, has been found to bear without apparent discomfort a submersion of eighteen hours in fresh water.

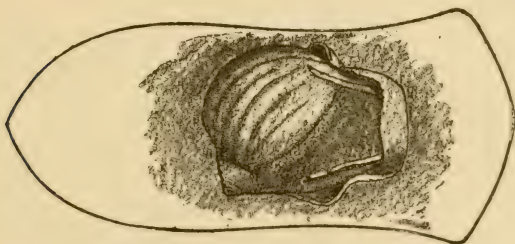
The largest species of the New Jersey coast is the big brown periwinkle (*Littorina irrorata*), which not infrequently measures upwards of an inch in length. It is readily distinguished by its robust, deeply-colored shell, which shows numerous prominent revolving lines on its surface. A much smaller form is the somewhat flattened and obtuse *Littorina palliata* (Pl. 1, Fig. 23), whose yellowish color, more or less speckled with brown, serves to distinguish it. It does not appear that the periwinkle is anywhere extensively used for food on the American coast, although prodigious quantities are periodically brought to and sent from the British markets. It is estimated that about the year 1865 the English periwinkle-supply amounted to not less than 2000

bushels per week during the months of March to August inclusive, and 500 bushels per week for the remaining six months. At least 1000 persons, mainly women and children, were employed in the gathering.

All the periwinkles are vegetable feeders, and are thus sharply defined in habit from the strictly carnivorous forms that have been thus far considered. It may be said *en passant* that with comparatively few exceptions all the snails whose shells have an even, round mouth are phytophagous in habit, living exclusively on vegetable substances, while those which have the shell aperture either truncated or produced into a canal of greater or less length are carnivorous. But both forms have the mouth provided with a peculiar chitinous or horny ribbon, known as the 'lingual ribbon' or 'radula,' which is closely beset with minute teeth, and by its backward and forward movement serves to rasp down objects that are brought in its way. It thus largely assists in the process of mastication; but probably one of its functions is the boring of the holes in 'foreign' shells through which an attack is made upon the enemy. The coiled lingual apparatus of the common European *Littorina litorea*, which has also been introduced on the New England coast, measures two and a half inches in length, and contains about 600 rows of teeth. The action of this ribbon may be well observed in the case of snails that creep up the glass walls of aquaria.

An exception to the rule which defines round-mouthed snails to be vegetable feeders is the

Natica (Pl. 1, Figs. 1, 4), one of whose best representatives is the common globular shell, of about the size of an apple, which is found almost everywhere along the beach. The natics, with strong carnivore propensities, are markedly predaceous in their habits, moving about rapidly in their sandy homes in quest of food, which they usually find in the shell-fish buried at some little depth beneath the surface. The making of the larger round holes which appear in such perfection on the shells of many of the bivalves is commonly attributed to the *Natica*, but the exact amount of guilt attaching to this creature has never yet been determined. The



NATICA EXTENDED.

Naticas have certain peculiarities of structure which it will be well to notice. You will observe, if you have succeeded in finding more than the empty shell, that the animal is completely retractile, and, further, that it has cased itself in by means of a horny lid or 'operculum,' which is attached to the under surface of the creeping disk or foot. This foot is greatly produced in front, where it is reflected back in the form of a hood, covering the

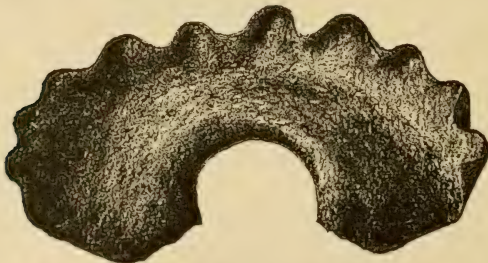
head and tentacles. It is a powerful excavating implement, and by it the animal is enabled to burrow in the sand like a mole. The *Natica* is blind, being destitute of eyes.

Of the three species of our coast the commoner forms are the two large species known as *Natica heros* (Pl. 1, Fig. 1) and *Natica duplicata* (Fig. 4):



NIDUS OF NATICA HEROS.

the first may be recognized by its larger size and more globular outline, and in having a deep hole (umbilicus) immediately alongside the aperture. In *Natica duplicata* the shell is more depressed and



NIDUS OF NATICA DUPLICATA.

somewhat oblique, while the umbilical aperture is closed by a thick 'callous' expansion. The third species is *Natica pusilla*. In your rambles

along the beach you cannot fail to have noticed peculiar gray, collar-like bodies scattered about, some of them forming almost complete circles, and measuring six inches or more across. Examined, these collars are seen to be made up of minute sand-particles glued together, and if held up to the light exhibit an almost innumerable number of translucent spots. These spots correspond to the positions of egg-cases which are distributed throughout the mass in a single layer, and in quincunx order. The whole is, in fact, the egg-ribbon or 'nidus' of the *Natica*—a construction unlike that of any other mollusk. Just how it is made still remains a mystery, but it appears that as it is extruded in the form of a viscous mass it is immediately moulded over the external face of the shell, which gives to it its peculiar spiral curve. The coating of mucus then draws to it the sand-particles which line it on either side. Two forms of this ribbon occur on our coast—one, a simple collar with a constricted neck, the other, sharply ruffled on its border. The former belongs to *Natica heros*, the latter to *N. duplicata*. The crowded little pouches, each of about the size of a spangle, which are frequently found on one side of the collar, are the egg-capsules of the dog-whelk (*Nassa*).

Of the several other species of marine snails occurring on our coast a few are found only at rare intervals, and not unlikely their shells have been merely washed hither without the animal itself living along the immediate coast-border. Among these are the auger-shell (*Terebra dislocata*), a com-

mon species of the Southern shore, wentletrap (*Scalaria*, Pl. 1, Figs. 12, 13), and purple (*Purpura lapillus*, Pl. 1, Figs. 9, 10). By pressing on the operculum of the last-named a fluid is released of a dull crimson color, much resembling some of the purples of antiquity; indeed, it was from one of the species of this genus that the ancients obtained some of their more highly prized dyes. The purple is a rough customer among the oyster- and muscle-beds, where its depredations extend as well to the dead as to the live animal. It is not, however, satisfied with these delicacies alone, but will also venture on limpets, barnacles, dead fish, etc. If by habit a pirate, the purple in turn suffers from the piracy of other animals, and largely so from the seemingly harmless hermit-crabs. These have on more than one occasion been observed to sally forth under protection of their borrowed castles, and clean out, so to say, the purple, dragging their unfortunate victim from the shell. In one such encounter, as narrated by Mr. Crowther, of Whitby, England, the attacking party were shielded by the shells of four distinct species of snails—a dog-whelk, periwinkle, troque, and purple.

Partaking largely of the habits of the purple is the ‘drill’ (*Urosalpinx cinerea*, Pl. 1, Fig. 8), a name suggestive of the methods employed by this animal to obtain its food. Like the last-named, it is a great destroyer of the oyster.

Our description of this section of the shore-fauna would not be complete without a special reference to the sandal or slipper-limpet (*Crepidula*) and the

very common (cylindrical) small shell that is found almost everywhere among the tide-water sedges or grasses. The latter is the *Melampus bidentatus* (Pl. 1, fig. 2), an air-breathing or pulmoniferous mollusk, like the common garden-snail, but requiring a certain amount of salt water for its happiness. Why this should be necessary is not exactly known, the animal breathing by means of a true lung, as in the case of all true land-snails (*Pulmonata*). The slipper-limpets are readily recognized by their somewhat boat-shaped shells, which are found either loose by themselves, or attached to other shells and stones, their outlines being largely modified according to the receiving substance. This modification extends in such varying directions that it is not yet clear what proportion of the ordinarily accepted specific characters is founded upon it. For the present, however, we recognize some three or four species as occurring on our coast: *Crepidula fornicata* (Pl. 1, Fig. 15), the largest form, which not rarely measures an inch and a half, or more, in length; *Crepidula glauca* or *convexa* (Fig. 25), a small humpy shell, whose presence appears to be generally associated with that of the small hermit and of *Nassa obsoleta*; and *Crepidula plana* or *unguiformis* (Fig. 26), with a nearly flat shell, which is frequently found within the apertures of other shells. The slipper-limpets have the habit of crowding upon themselves, or of 'bunching,' so to speak; they may accordingly be picked up in accumulated masses, and this is especially true of the more northerly shores. Closely related to the preceding is the crucible-

shell (*Crucibulum striatum*, Pl. 1, Fig. 32), which is, however, rarely seen with us.

No true limpets, which are rock-loving animals, are known to inhabit the New Jersey coast.

CLAMS AND THEIR ALLIES (BIVALVES).

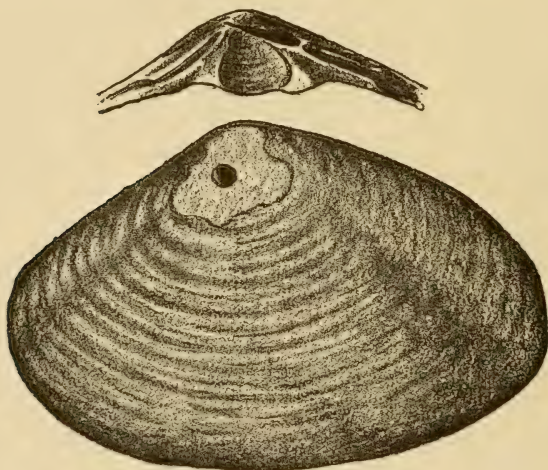
We call these shells 'bivalves' because they are each made up of two pieces or valves, which lie on either side of the animal, and are respectively designated the 'right' and the 'left' valve. But how do we determine which is which? Barring the case of the oysters, scallops, and a few of their friends, the bivalves or headless mollusks have the valves of the shell almost invariably equal, and, with insignificant exceptions, the beaks of the valves, known to systematists as the 'umbones' (singular, 'umbo'), are directed forward. Bearing this fact in mind,—*i.e.*, knowing which is front and which back,—it is an easy matter to determine the two sides. Possibly you may have stumbled across one of the hard-shell clams from which the animal has been dislodged, but which still holds both valves together. The valves in this case will be wide open, and are pulled and held in this position by an elastic ligament which runs along the back of the shell. Look on the interior surfaces of the valves, and you will observe, both in front and in the rear, a nearly round, impressed scar, the positions of which correspond in the two valves. Uniting the scars of the opposite valves, there were in the living condition of the animal two stout muscular bundles, whose contraction, regulated by the

will of the animal, operated in the closing of the shell. It is the action of these 'adductor' muscles pulling together which renders the opening of clams such a hopeless and discouraging task to the uninitiated. But traverse the adductors with a knife-blade, and the shell immediately opens. And so, on the death of the animal, when the adductors no longer possess vitality, the valves of the shell are pulled apart by the elastic ligament, which always suffers compression in the closed condition of the shell. This accounts for the apparent anomaly that dead shells are almost invariably open.

If a living clam be carefully opened, it will be found that a delicate membrane lines the shell on each side, reaching almost to the free edge of the shell; this is the so-called 'mantle.' Immediately following the mantle we meet on either side with a pair of membranous, leaf-like organs, the gills, and between the gills again, occupying the centre, is the tough, fleshy mass which constitutes the 'body' and 'foot' of the animal, the part which is so generously partaken of by all lovers of the shell-fish. Into this fleshy mass the aperture of the mouth opens, and in it is contained the greater part of the alimentary tract. At the back of the animal the mantle-margins are united to one another, and the mantle is itself drawn out into a double tube or 'siphon,' through which water enters and leaves the interior of the shell. Not all bivalves have these siphons, but where they are well developed and retractile, a peculiar inflection may be observed in the impressed line which

on the interior of the shell connects the adductor impressions. This sinuall inflection, or 'pallial sinus,' is one of the most important characters to be noted in the shell, since it serves to indicate a prominent feature in the structure of the animal.

We recognize two hard-shell clams on our coast, one having an obliquely oval shell, the quahog (*Venus mercenaria*), and the other, with a more nearly

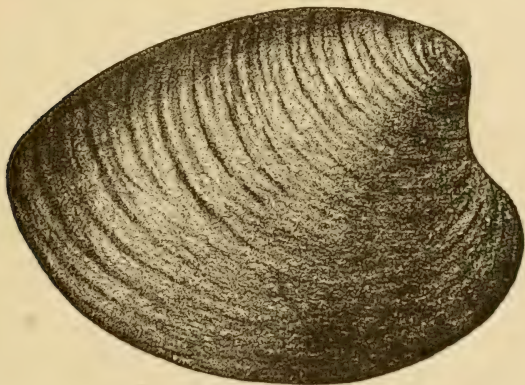


SURF-CLAM (*Mactra solidissima*).

triangular or equilateral shell, the Mactra (*Mactra solidissima*). The former is the edible species, although by some the Mactra is not completely denied a hearing. The latter, also known as the 'sea-clam' or 'surf-clam,' inhabits the sandy coasts, where it lies buried just beneath the surface; but it may be occasionally seen skipping about

by means of its active and greatly elongated foot. It seems never to construct a permanent burrow, thus differing from the 'long-clam' or 'sand-clam,' to be noticed hereafter. The shells, which, when full grown, measure as much as six inches in length and four inches in height, were formerly used by the Indians as hoes in the hilling of corn. Two smaller species, *Mactra ovalis* and *M. lateralis*, are abundant at some tides.

The round clam or quahog, which is the clam of the New York and Philadelphia markets, inhabits the muddy bottoms of bays more particularly from



QUAHOG (*Venus mercenaria*).

low-water mark to about 30 fathoms. Its habitat extends along the entire American coast from Cape Cod to Florida, but north of Cape Cod it is of rare occurrence. The quahog is a large and powerful shell, whose outer surface frequently shows signs of considerable erosion. From the interior

purple margin the Indians cut their purple wampum (shell-money), the white wampum being obtained from the columellar axis of the pear-conch or winkle (Fulgur). The word 'quahog' appears

to be a corruption of the plural Poquahock, or, as it is written, 'Poquahauges.'



SAND-CLAM (*Mya arenaria*).

Careful observers of the ocean beach will have noticed from time to time little jets of water issuing from scattered holes in the sand; or frequently the shallow waters of pools may be observed twirled round into eddies by suction and ejection currents coming from below. The author of this play of water is the sand-clam (*Mya arenaria*), which lies buried a few inches below the surface, whence it communicates with the outer world by means of its extended siphon. Through this siphon, which is in reality a double tube, water-currents are passing both inward and outward, bringing necessities to the secluded creature, and carrying from it the waste products. The depth to which the animal burrows will depend closely upon the length of its respiratory siphon. Although it measures but a

few inches in our sand-clam, in other forms it considerably surpasses a foot, and, indeed, in a species from the Californian coast (*Glycimeris generosa*) it reaches a full yard, with a thickness somewhat exceeding that of a stout broom-handle. The sand-clam, which is abundant almost everywhere in the North in the tidal zone—estuaries, muddy inlets, and sandy shores—is a broadly distributed species, extending its range eastward to the British Isles and the continent of Europe. In the New England markets it is a common article of sale, but in New York and Philadelphia its place is almost entirely taken by the hard-shell clam or quahog. The Indians appear to have been very fond of these clams, which were known to them as Sickishuog. John Winthrop, in a communication made to the Royal Society of England in 1634, thus describes the species: “Clams—white. Their broth is most excellent in all intermitting fevers, consumption, etc. These clams feed only on sand.”

On the New Jersey coast the sand-clam is sometimes called, after the Indian name, ‘maninose’ (corrupted to ‘nannynose’), and, to distinguish it from the quahog, the ‘soft-shell clam.’

It frequently happens as the result of a storm that large cakes of a stiff gray or blue clay, more or less firmly matted together by vegetable fibres, and in some localities having a peaty aspect, are cast upon the beach. These masses are the abiding-place of great numbers of an interesting boring mollusk known to conchologists as *Petricola* (Pl. 2, Fig. 20), the ‘stone-dweller,’ which has forced its way in by

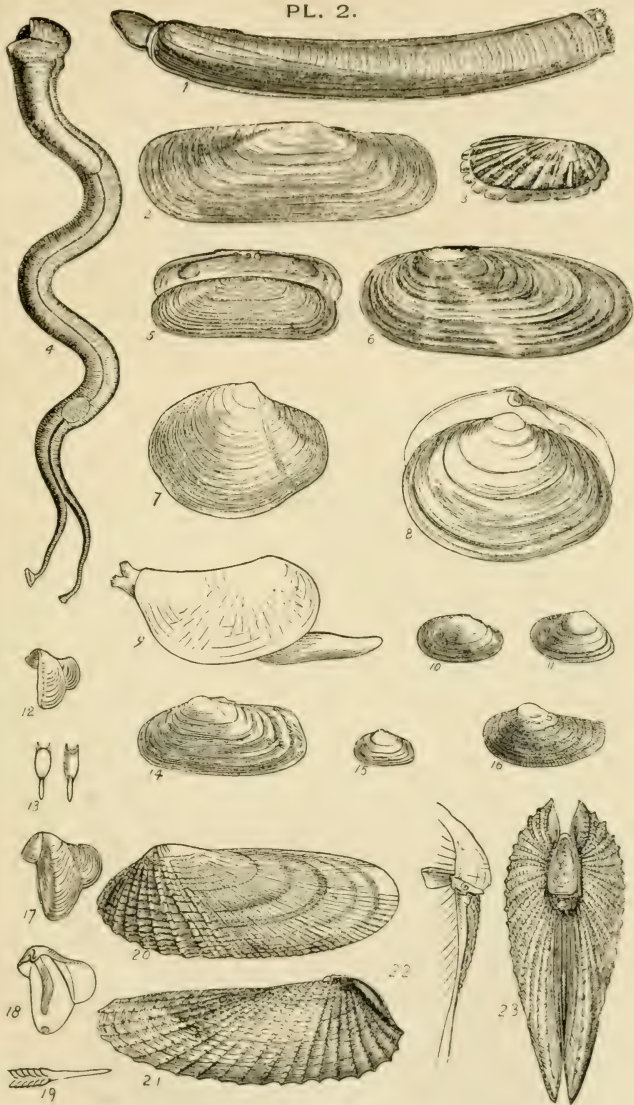
a process which has not yet been clearly made out. The animal is provided with a double respiratory siphon, which can be extended to a length considerably in excess of that of the shell itself. When placed in a dish of sea-water, the animal, after it has fully recovered from its consciousness of danger, slowly begins to thrust out this respiratory apparatus, whose action can now be clearly followed. If there should happen to be minute particles of foreign matter in the water, it will be observed that these are attracted in the direction of the lower division of the siphon, while they are just as positively repelled from the upper. This indicates that a current of water sets in through the lower or 'in-current' orifice, and that a similar current passes out at the same time through the upper or 'excurrent' orifice. A perpetual circulation is thus kept up about the body of the animal, feeding the gills, and taking with it a certain amount of nutriment necessary to the existence of the animal. This arrangement is found in all the siphonated bivalves.

Like other shell-fish that bury themselves in the sand or mud, the *Petricola* doubtless seeks its seclusion from motives of self-protection. By many it has been supposed that the boring is accomplished by a peculiar revolution of the shell, during which the serrated ridges on the surface would act like a rasp, wearing and tearing as the work of excavation progressed. That this is not likely to be the true method of operation is indicated by the fact that there are a number of true stone-borers, which have an ornamentation almost identical with that cover-

PLATE 2.

FIG.

1. *Solen ensis*.
2. *Solecurtus gibba*.
3. *Solenomya velum*.
4. *Teredo navalis*.
5. *Solecurtus divisus*.
6. *Siliqua costata*.
7. *Anatina papyracea*.
8. *Cochlodesma Leana*.
9. *Pandora trilineata*.
10. *Tellina tenta*.
11. " *tenera*.
12. *Teredo navalis*.
13. Pallets of ship-worm.
14. *Saxicava Arctica*.
15. *Corbula contracta*.
16. *Lyonsia hyalina*.
- 17, 18. *Xylotrya fimbriata*.
19. Pallets of *Xylotrya*.
20. *Petricola pholadiformis*.
- 21, 22, 23. *Pholas costata*.



ing the shell of *Petricola pholadiformis*, and in which, after the completion of the work of boring, the projecting points on the shell are perfectly clear and sharp, and not rubbed down as we should naturally expect to find them after the hard work of rock-abrasion. Such a shell is the *Pholas*, of which three species are represented on the New Jersey coast. The largest of these, *Pholas costata* (Pl. 2, Figs. 21-23), which measures about six inches in length, is very generally represented only by fragments of the shell, and it is still doubtful whether it normally inhabits this part of the coast. It is more properly a species from the South (although observed as far north as New Bedford), where it may be found at some little distance beneath the surface in the mud-banks which are exposed at low water. The other two species, *Pholas truncata* and *P. crispata* (Pl. 3, Figs. 1, 2), are very much smaller, and, while their shells are ribbed anteriorly, they lack the full series of spinose riblets which so regularly diversify the shell of the larger form. In the latter species the shell 'gapes' broadly at the two ends, the posterior opening permitting of the extension of a very powerful and muscular siphon. It is a common habit with *Pholas crispata* to bore into rock, and specimens of bored-rock fragments in museums are not rare. The collections of the Academy of Natural Sciences of Philadelphia contain a remarkable block of gneiss which is bored in this manner. It has been suggested that the process of boring may be entirely performed by the foot taking up particles of sand and rubbing these

against the rock in concentric lines. However this may be, it is certain that the hole is very evenly cut, and that it is increased in size in conformity with the development within the rock of the animal itself.

A rather remarkable form of borer, which was first detected within the shells of the oyster at Tottenville, Staten Island, is the *Diplothyra Smithii*, a very much smaller shell than either of the pholads, and perhaps more nearly recalling the true ship-worms. The latter (Pl. 2, Figs. 4, 12, 13), by reason of their depredations, are the most interesting of the boring Mollusca. They are largely inhabitants of the tropical waters, but have in the timber of ships been introduced almost everywhere over the wide sea. The body proper of this singular creature is usually very small, but through the great elongation backward of the siphons the animal is made to appear worm-like (although it has no near relation to the worms), and to attain a length varying in the different species from one to three or even six feet. The shell is compact, ridged, and open at both ends, and only sufficiently large to cover the anterior or body-portion, the animal thus appearing naked. Beginning in very early life, when frequently not over two weeks old, and when only of about the size of the head of a pin, the young ship-worm or *Teredo* puts itself to the task of boring, selecting for its base of operations all forms of wood or timber that may be immersed in water, whether the belongings of ships, dikes, piles, or piers; indeed, one or more forms even

attack the floating cocoa-nut. The rapidly-forming burrow follows in a sinuous line the grain of the wood, passing out of the way of knots, and conscientiously avoiding the burrows of confederate workers. In this manner a piece of wood is soon honey-combed. The entrance is made by a minute hole, the size of the burrow increasing with the growth of the animal. A lining of white calcareous matter usually extends along the entire length of the burrow, to the farther end of which the two valves of the shell are attached.

It is well ascertained in the case of the ship-worm that the burrow is largely, or even principally, excavated by shell-abrasion, although perhaps the exact process has not yet been clearly made out. Large quantities of the wood-dust are frequently found within the intestine of the animal, and it appears not unlikely that some of it is intentionally swallowed, and even used for nourishment. The ravages of the ship-worm may be such as to destroy within a very short time the stoutest timber; indeed, it is said that piles that had been driven only six or seven weeks on the Dutch coast were found at the end of that



WOOD BORED BY
SHIP-WORM.

time to have been completely eaten through. It seems not unlikely that some of the breakages in the Holland dikes are to be attributed to weakness caused by this enemy to wood. The metal casing of ships' bottoms has pretty effectually stopped all attack in this direction, and much the same result has been obtained from painting wood with creosote oil.

The best-known species of ship-worm is the *Teredo navalis*, which appears to have been introduced upon our coast from Europe; its calcareous tube measures as much as two feet, or more, in length. It breeds in middle spring, and the eggs are said to be developed by millions from a single individual. The young are provided with eyes, which, however, disappear in later life. Closely related to this species is the form known as *Xylotrya fimbriata* (Pl. 2, Figs. 17, 18, 19), which differs mainly in the outline of the minute stylets or 'pallets,' which project from the posterior portion of the siphonal tube.

Another form of borer, much rarer with us than in the North, is the *Saxicava Arctica* (Pl. 2, Fig. 14), a small shell somewhat resembling the sand-clam, which not infrequently attacks the softer limestones.

Not the least interesting of our coast Mollusca is an individual which has thus far escaped the clutch of the epicure, but which, if delicacy of flavor counts for anything, is not unlikely to gain a prominent position on the table in the near future. This is the razor or so-called razor-fish (*Solen Americanus*,

Pl. 2, Fig. 1), whose long and narrow parallel-sided shell is familiar to almost every one on the beach. The clean pinkish- or yellowish-white flesh, the greater portion of which forms a narrow cylindrical 'foot,' is even now esteemed a delicacy by many. The animal may be found at low-water mark, buried almost vertically in the sand, and to a depth not seldom of two or three feet. Where thus deeply buried it comes frequently to the surface, so that it may receive the necessary food-supplying water through its short siphonal tube. It has been observed that the razor takes cognizance of passing shadows on the water, as when the hand is passed over the position occupied by the siphonal orifices, and this, too, when the rest of the animal is completely covered over. The supposition that the animal was by some means enabled to see from the rear will to most persons appear erratic; nevertheless, careful examination of the siphonal margin has revealed the existence there of minute black specks, which appear to have the structure of visual organs. Thus we are taught that the special sense organs need not be situated in the head, a condition which also obtains with many other forms of animals. A second species, allied to the preceding, is the green razor (*Solen viridis*), which rarely attains a length much exceeding two inches, while the former not infrequently measures full six inches. Several other species of bivalves have more or less the elongated form of the razor, but in none does the shell attain the proportional length seen in that species. Eye-specks, of an orange color, are pres-

ent in the siphonal region of *Solecurtus gibbus*, a common mud-burrower of the ocean front (Pl. 2, Fig. 2).

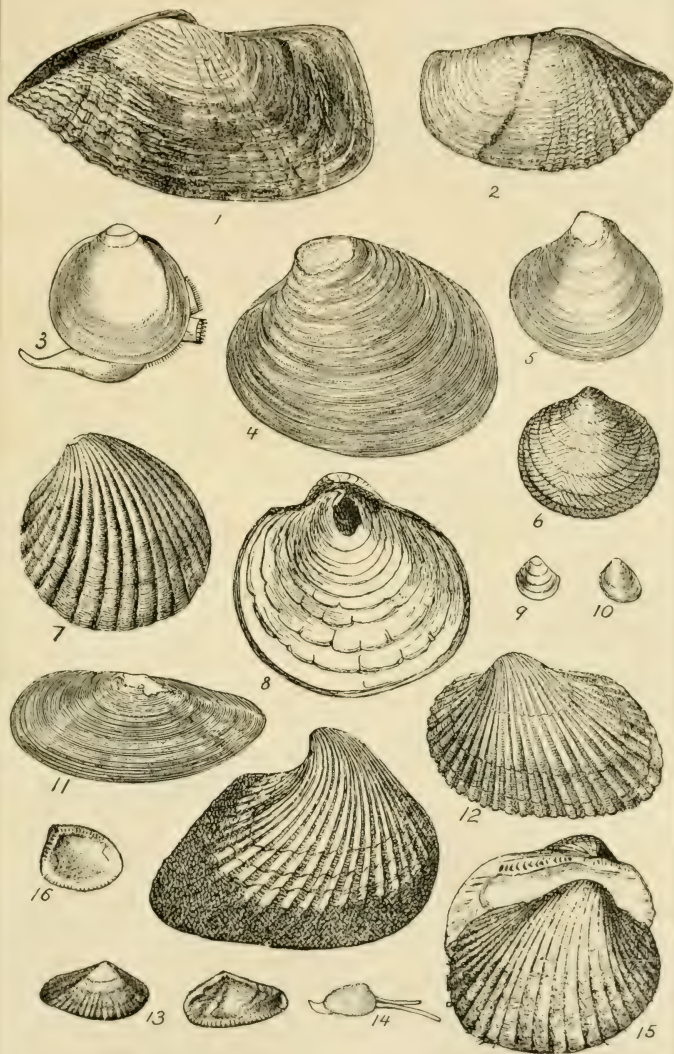
Before finally parting from our siphonated friends of the coast it may be well to turn our attention for a moment to a number of small and insignificant-looking shells, which are at times fairly abundant, their fragments, indeed, frequently making up much of the long white lines which define the boundaries of the surf. These are the tellens and their allies the wedge-shells (Donax, Pl. 3, Fig. 13). In both of these groups, as a distinguishing peculiarity, the beak of the shell is placed nearer the posterior margin than the anterior, thus making the front of the animal very long in comparison with the back. In by far the greater number of the bivalve shell-fish the reverse is the case; in a few, again, the two sides are nearly equal. The shells of *Tellina* (Pl. 2, Figs. 10, 11) may be recognized by their rounded outlines, the position of the beaks, and the minute teeth by which the valves hinge. In the wedge-shells, which, though small, are conspicuous by their beautiful coloring, the shell is clearly wedge-shaped, with nearly direct outlines.

One of the rarer shells of the coast, although extending in its range from Maine to Florida, is the delicate *Pandora* (Pl. 2, Fig. 9), which can be almost immediately recognized by the flatness of its beautifully-arched valves, and their pearly structure. Observe that one valve is considerably smaller than the other.

PLATE 3.

FIG.

1. *Pholas truncata*.
2. " *crispata*.
3. *Cardium Mortoni*.
4. *Cytherea convexa*.
5. *Astarte castanea*.
6. *Lucina divaricata*.
7. *Cardita borealis*.
8. *Anomia ephippium*.
9. *Gouldia mactracea*.
10. *Nucula proxima*.
11. *Yoldia limatula*.
12. *Arca transversa*.
13. *Donax fossor*.
14. *Tellina tenera*.
15. *Arca pexata*.
16. " *ponderosa*.



OYSTERS, SCALLOPS, MUSCLES, AND ARKS.

The oyster is so familiar to everybody that it scarcely needs description. Still, there are a number of points connected with its structure and history which may not be generally known, and may consequently be touched upon with advantage. In the first place, let it be said that there are two generally recognized species or varieties on our coast,—one known as the Virginia oyster, of an elongated form, and the other, deeply scalloped, the Northern oyster (*Ostrea borealis*). But the shell of the oyster varies so greatly, depending for its form so much upon the shape of the object upon which it immovably attaches itself in later life, that it becomes a matter of great difficulty to determine the proper limits of specific variation; and, indeed, as far as the two forms above noted are concerned, it is very doubtful if they do not in reality belong to a single species. In both, as in nearly all oysters, the left valve is the larger of the two, and it is upon this that the animal rests. The two are brought together by means of a single powerful muscle (adductor), whose attachment to the shell leaves the dark sub-central impression which is frequently called the ‘heart.’

Oysters are marine in habit, but they seem able to endure a certain amount of exposure to fresh water, as in the mouths of estuaries and bays, which constitute their chief abiding-place. The ‘banks’ or ‘reefs’ rise to within a few feet of the surface, and in many regions are even exposed

dry during low-water. One or more forms grow on the roots of trees, such as the mangrove, on which they remain exposed for hours at a time above water. The great thickness of the shell in many individuals indicates a long life-period for the animal, which has been estimated by some, but probably without sufficient basis, to be as much as a hundred years. The different layers of the shell indicate distinct periods of rest in its development, but at what regular (if regular) intervals these periods follow one another is still an open question. In the east-coast oysters, whose most extensive head-quarters appear to be Chesapeake Bay, the shell rarely attains a greater length than one foot or 15 inches; but foreign and fossil species are known which far exceed these dimensions. Thus, a species from the Middle Tertiary deposits of Europe (*Ostrea crassissima*) measures nearly or fully two feet in length; the *Ostrea Titan*, from a somewhat later deposit in California, measures six inches through the thickness of the two valves, while a recent species (*O. Talienwanensis*), from the Bay of Taichou, Japan, grows to a length of even three feet. Careful investigation has shown that the American oyster will grow to a length of nearly four inches in about two years, and it is conjectured from this that in some four years after its escape from the egg the animal is approximately adult and marketable.

Oysters appear to thrive best in estuarine coves and inlets where the bottom is not liable to shift to any great extent, and where the depth of water

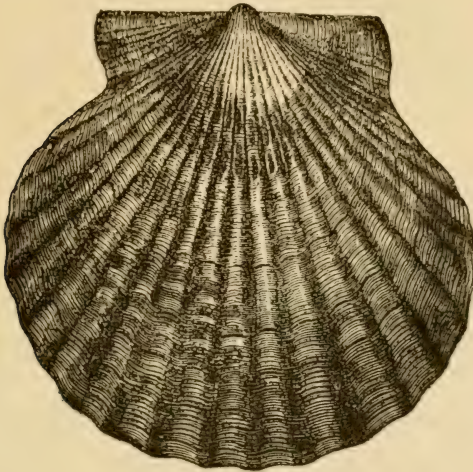
does not much exceed 18 or 20 fathoms. Their food consists principally of minute larvæ, infusorians, and the lowly-organized plants known as Diatoms, but they do not refuse either crustaceans or mollusks, provided these be small enough, and even the inorganic earths form part of their nutritive material. In a general way they might be said to be omnivorous. The principal spawning season about the Chesapeake extends through the months of June and July, but some individuals may be found with spawn throughout almost the entire year. The eggs, which have been estimated to be contained to the extent of 100,000,000 in a single large female, measure about the one-five-hundredth of an inch in diameter, and give birth to active little creatures, the fry, which are early provided with a rudimentary shell. It appears that under favorable circumstances the fry becomes attached within a day after its liberation; in this condition the oyster young is known as 'spat.' Spawning begins at about the age of one year. The notion that oysters are harmful during all but the so-called seasonable months has nothing to support it beyond the fact that in the warmer months the flesh loses in general delicacy and flavor.

A near ally of the oyster is an irregular lustrous shell, about one inch in diameter, which more generally occurs black or bluish-black on our coast, and is known to conchologists as *Anomia* (Pl. 3, Fig. 8). It is rarely found with both valves attached, the valve commonly found being the upper convex

one. The lower valve is nearly flat, and contains a deep fissure or hole at one extremity through which the animal passes a bundle of horny threads—the byssus—for the purposes of attachment. Our *Anomia* appears to be undistinguishable from the common European species (*Anomia ephippium*), and this may also be the case with some of the varieties of the oyster just described.

He who has but once trod the Jersey sands knows the scallop, whose radiately-ribbed and symmetrically-formed shell is one of the commonest objects on the beach. Indeed, during recent years it has been steadily growing in favor as an article of food; and why it should be less palatable than its first cousin, the oyster, is a little difficult to say. The scallop, so called from the service to which the shell was formerly put in ‘scalloping’ oysters, inhabits the sub-tidal zone to a depth of some 250 feet or more, frequently forming by its aggregations vast banks. The animal rests on its right valve, which is in almost all cases more convex than its fellow. Beneath, or at the base of, the anterior ‘ear’ of this valve will be found a fairly profound notch, which marks the passage of the byssal fibres secreted by the foot. Considerable interest attaches to this animal as being the first among the bivalve Mollusca in which, it was claimed, the presence of visual organs had been detected. If the margin of the mantle be examined it will be found to be double, the inner piece hanging like a finely-fringed curtain. Along its base are scattered a number of small black or blue specks, to which, for apparently

good reasons, the function of eyes has been ascribed. Possibly, however, they may be only phosphorescent or illuminating organs, without in themselves being capable of receiving images.



SCALLOP (*Pecten irradians*).

The scallop of the New Jersey coast is the *Pecten irradians*, a shell measuring some three inches each way, and crossed by about twenty elevated ribs. On account of its varied and beautiful coloring, ranging from white through shades of orange, brown, red, and purple, it is eagerly sought after for mantel-ornamentation, the making of card-holders, pincushions, etc. A much larger and more northerly species (*Pecten Magellanicus*), which is almost entirely wanting on the sands, has been dredged in abundance in Raritan Bay and else-

where. The scallop, unlike the oyster, is a fairly active creature, moving about with rapidity by means of its finger-shaped foot. In the young condition the animal swims freely through, and on the surface of, the water, propulsion being effected mainly by the sudden opening and closing of the valves. A scallop placed high and dry will at slow intervals open its shell, and then suddenly close it with a peculiar thud, a performance that is repeated until the animal is wellnigh dry. The part of the scallop that is used for food is the thick white muscle which holds the two valves of the shell together.

A few words about arks and their allies. These can be immediately recognized by the large number of teeth on the hinge-line, by means of which the two valves are kept firmly interlocked. In the arks proper (Pl. 3, Figs. 12, 15, 17) these minute comb-like teeth are arranged in a continuous linear series, but in the pearl-lined *Nucula* (Figs. 10, 16) and in *Yoldia* (Fig. 11) the series is interrupted, and broken in outline. In the arks the shell, when not badly worn, is coated with a heavy epidermis, usually of a dark brown color. Many of the species spin a stout byssus, which serves as an anchor-line of attachment to the surfaces of stones, rocks, etc. The shells of three species are found on our coast, each well defined by peculiarities in their outline. The rounded form (*Arca pexata*, Pl. 3, Fig. 15), which differs from most arks in having a minimum of space between the two valves, is further distinguished by the possession of red

blood; hence it has acquired the name of *bloody clam*.

A visit to the muscle-shoals, which are to be found on the borders of salt marshes, or where along inlets the muddy bottom is exposed for some time during low water, cannot but prove interesting and instructive. Two forms of muscle will very generally be found here, aggregated in large numbers and clusters. One of these, pointed and wedge-shaped in outline, with a dark blue epidermis and a purplish or horn-colored shell, is the edible muscle (*Mytilus edulis*), a common form of both the American and European coasts, and perhaps the most widely distributed of all known Mollusca. It occurs in great clusters, matted to-



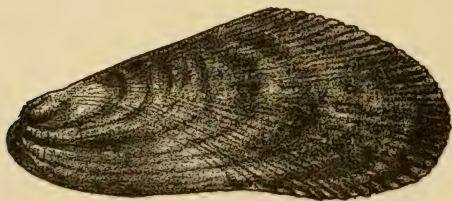
EDIBLE MUSCLE.

gether by byssus, which also attaches it to stones, piles, wrecks, and floating bodies of all sorts. Although more commonly an inhabitant of the tidal zone, it is also found in depths ranging to 300 feet or more. This species has been put to little economical use in this country—although by many considered to excel in flavor the ordinary clam—but in various parts of Northern Europe it is esteemed a very desirable article of food. The annual muscle-consumption in the markets of Edinburgh and Leith is estimated at 400 bushels (about 400,000 muscles). In some of the German waters the muscle-fishery is conducted by placing boughs of trees in the shallows inhabited by the

mollusk, and allowing the shells to accumulate on these boughs for a period of several years. They are then raised, the quantity sold by weight, and distributed over the interior of the country.

The muscle when first hatched is an active free-swimming little creature, which attaches itself when no larger than the head of a pin. But much later in life it still possesses the power of disengaging the attaching byssus, and securing a new anchorage when such is needed. By alternately passing forward its delicate threads, the animal pulls itself along to a selected locality, much in the manner that is adopted by many spiders in securing their prey.

Readily distinguished from the edible muscle by its rounded anterior outline and the plications or



HORSE-MUSCLE.

radiating lines extending down the sides of the shell, is the so-called horse-mussel (*Modiola plicatula*), like the former an inhabitant of the shallows about tide-water. Here, in the somewhat peaty soil, they are frequently found burrowing in vast numbers, so closely packed together as to form a true stratum. The shells are often much eroded

over the beaks, and in acidulated waters sometimes nests of the epidermis alone will be found, the limy parts having been completely dissolved away. This species enters freely into brackish water. A second species, smooth, and of much larger size, measuring as much as six inches in length, is the *Modiola modiolus*, a common form of moderately deep northern waters.

II.

SQUIRTS, POLYPS, AND JELLY-FISHES.

SOME of the pleasant minutes whiled away in the water can be advantageously put to collecting, and the bather who loiters among the grass-grown piles that here and there lift their hoary heads out of the water, or examines the wreck of some unfortunate merchantman, cannot fail to meet with a number of curious and interesting objects, which otherwise might have readily passed among the unknowables of the sea-border. One or more forms of sea-urchins or 'sea-eggs,' various squirts, polyps, and corallines, and the goose barnacle, find here a congenial home, which already in olden time had been discovered and made useful by the edible muscle. Unfortunately, almost the entire New Jersey coast is destitute of real rock, and consequently lacks those cool rock-bound retreats which on the New England shores delight the star-fish and the sea-anemone. This deficiency is in a measure made good by the enclosed areas of piers and wharves, which offer a safe harbor to a number of forms which, in the matter of home comforts, could obtain but little encouragement from the arid sands.

Among these, perhaps the first to attract our attention will be a small rounded yellowish body, not much more than a half-inch across, which is found

adhering to the piles. Press gently with the finger—the animal contracts, and while contracting throws out a double jet of water from two chimney-pot openings situated on its surface. The animal is one of our commoner forms of sea-squirts, known to naturalists as *Molgula Manhattensis*. Through its pellucid outer tunic the color of the viscera can be indistinctly seen. This species also frequently attaches itself to floating sea-weed, and is then drifted in to shore; or it may be found attached to the nodding fronds which battle with the waves.



MOLGULA
MANHATTENSIS.

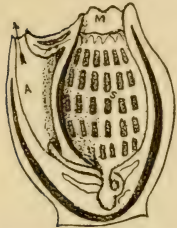
The sea-squirts are in many ways interesting animals, especially since it has been shown that in their young condition they present many points of resemblance to the vertebrate or backboned animals. Thus, the larva of most species has a long tail, a rudimentary spinal column, and a long nerve-tract, terminating in a brain, which occupies the same relative position to the spinal column that the same tract does in the higher animals. Indeed, so similar is the larva of certain forms to a tadpole as to carry with it a conviction that the two cannot be very far removed



LARVA OF TUNICATE.

from each other. But in the mature form of nearly all squirts the tail becomes absorbed, and with it disappears what there was to represent the spinal column, and also much of the nerve apparatus—a case of true degeneration. One of the chimney pot openings on *Molgula* conducts into

a peculiar sieve-like chamber—whose walls are made up of delicate vessels—into which food particles are carried, and through which the admitted



STRUCTURE OF A TUNICATE. M, mouth; S, respiratory sac; A, atrial chamber.

water passes into a second chamber, which also receives the alimentary canal. From this second chamber the water, which bathes the blood-vessels forming the meshes of the sieve-like respiratory sac, is expelled through the second chimney-pot opening, and thus a constant circulation is kept up. A remarkable fact connected with the circulation of this animal is that the heart, which lies near the base of the respiratory sac, after beating a short time suddenly stops, and that with each renewal of action the direction of the blood-current is reversed. From the peculiar external tunic which encases the animal, the group to which the squirt belongs has been designated the Tunicata.

A considerably larger form than *Molgula* is that which has received from fishermen the name of 'sea-peach' (*Cynthia*), in allusion to the similarity in form and coloring existing between it and the peach. Other species of nearly identical structure and habit are the 'sea-pears' (*Boltenia*), which are supported on long slender stalks, measuring as much as a foot or more in length. These are almost invariably covered with foreign associations of plant and animal matter, presenting a coarse and untidy appearance.

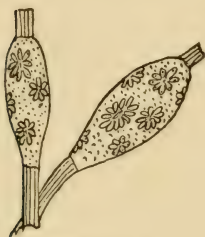
In the tangle of eel-grass which here and there shows itself you may have had occasion to notice that many of the blades are encased in a gelatinous or slimy substance, whose surface exhibits beautiful stellate impressions or markings. The whole encrusting mass is a compound tunicate or ascidian, the rays of the different stars being the individuals that make up the colony. The sharp eye, or, still better, a magnifier, will detect in each ray a minute speck, which corresponds to the incurrent opening in the common sea-squirts, and through which the water passes in the ordinary fashion. In the centre of the star is a second speck, which is the common excurrent aperture for the different individuals of the group. Although much reduced in size, this compound tunicate, known as *Botryllus*, is constructed on the same general plan as the larger forms above described. In color it varies considerably, but generally it is of a livid green or a slimy white. Another interesting form which can be sometimes found in the grass occurs in more or less globular or flattened jelly-like masses, ranging in size from an orange to a big cake, and having a color much like that of boiled salt pork, whence the name 'sea-pork.' The stellate



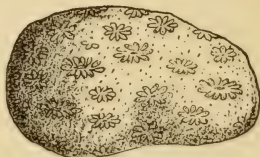
BOTENIA.

markings are here similar to those seen on *Botryllus*.

There are a number of free-swimming or pelagic tunicates, some of which approach our coast. One of the commonest of these is *Salpa spinosa*, whose



BOTRYLLUS.



'SEA-PORK' (*Amoræcium*).

compound chains, measuring as much as a foot in length, of perfectly transparent individuals, sometimes cover the sea over a vast expanse. Another, the *Pyrosoma*, a much rarer form in this region, is highly phosphorescent, and lays just claim to being considered one of the lamps of the sea.

POLYPS.

The same unsightly sticks of timber that offer refuge to the squirts will probably also be found to harbor quantities of the delicate feathery tufts which are almost everywhere scattered over the beach, and which in the popular mind are associated in structure with the 'sea-weed,' a term that has much to answer for in receiving under its wing a multitude of objects that do not belong there. These feathery tufts, which are familiar to many

under the name of sea-fir, sea-moss, or *Sertularia* (Pl. 4, Figs. 7, 10), are, indeed, far removed from plants, and even far above the lowest forms of animal life. To those who are acquainted with the little polyp of our fresh-water streams and ponds, the hydra, it is but necessary to say that the sea-fir is practically only a compound colony of this animal, which has become covered over by, or encased in, a horny sheath. Cast your eye over a single twig of the Sertularian, and note the minute scale-like bracts which run off at an acute angle with it. These, when magnified, are seen to be hollow sheaths or cups (*thecæ*), each of which, during the life of the animal, contained a minute polyp, to all intents and purposes identical with the hydra. The different polyps were united with one another by means of a common stalk which occupied the centre of the connecting axis or twig. But what is the polyp itself? A hollow little body, with an opening at one end, the mouth, and a circle of hollow arms or tentacles, an out-growth of the body-cavity itself, surrounding the mouth. It might be likened to a glove closed at the bottom, and with a single rupture (corresponding to the mouth of the polyp) at the base of one of the fingers. This colony has become compound through repeated budding, the individual polyps after they have once budded out contributing by way of nourishment to the welfare of the commu-



POLYP OF SERTULARIA.
magnified.

nity at large. Each little active polyp is situated in its own chitinous cup, the different cups being arranged in a double series along the connecting axis. Between these cups, at certain seasons of the year, may be observed a number of larger and somewhat urn-shaped bodies, the gonothecæ, from buds contained in which the eggs necessary for the perpetuation of the species are developed. These liberate minute ciliated bodies, known as 'planulæ,' which, after enjoying a short independent existence of their own, attach themselves, and grow up into the grand-parental form.

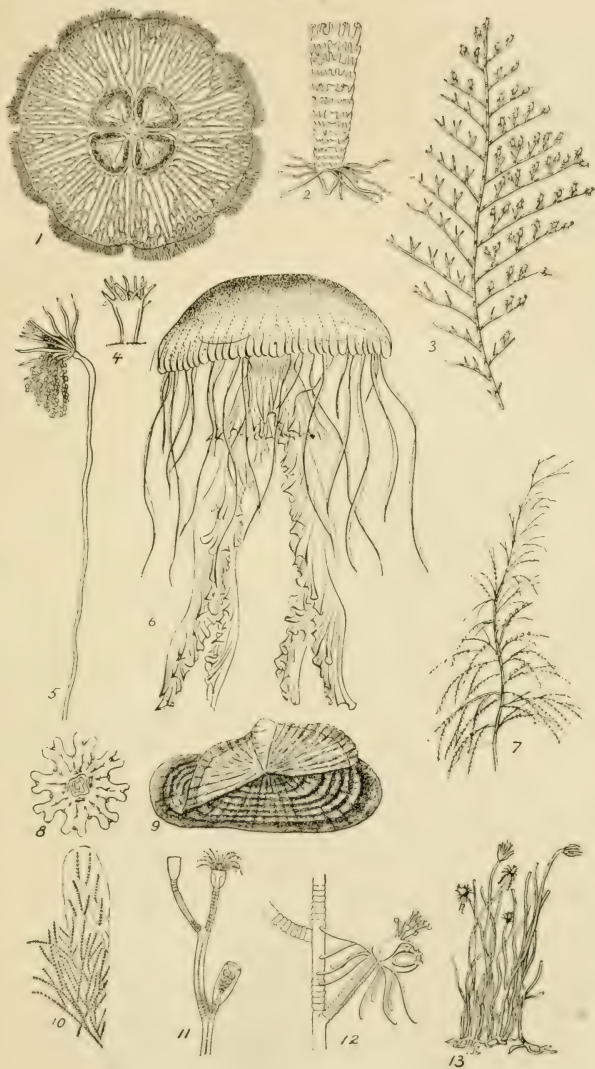
The commoner of the two forms of sea-fir found on our coast is the silver sea-fir (*Sertularia argentea*, Pl. 4, Fig. 7), so named from the general whiteness of the fronds, and found from low-water mark to a depth of 100 fathoms or more. It is the common 'sea-moss' that is so extensively displayed in the shops along the sea-shore, and used by florists for decorative purposes. A smaller species, the dwarf sea-fir (*Sertularia pumila*, Fig. 10), attaches itself to the ordinary brown rockweed or fucus, also to pebbles, and to various dead and living shells.

Growing in bunches much like the sea-firs, but appearing thinned out by reason of the distance of the polyps from one another, is the form known as Penaria (Pl. 4, Figs. 3, 12), whose fronds can be easily distinguished by the black color of the branches. The polyps which terminate the branches are exceedingly minute, of a bright red color, and furnished with three circles of tentacles. In probably

PLATE 4.

FIG.

1. *Aurelia flavidula*.
2. Strobila of *Aurelia*.
3. *Pennaria tiarella*.
4. Early strobila stage of *Aurelia*.
5. *Parypha crocea*.
6. *Dactylometra quinquecirra*.
7. *Sertularia argentea*.
8. Young *Aurelia*.
9. *Velella mutica*.
10. *Sertularia pumila*.
11. *Obelia commissuralis* (highly magnified).
12. Hydroid of *Pennaria* " "
13. *Tubularia indivisa*.



all the animals of the class we are now considering the extremities of the tentacles are provided with peculiar 'nettle-cells,' which by a special arrangement can discharge from their interiors small barbed bodies or styles useful as weapons of both offence and defence. In *Pennaria* nettle-cells similar to those of the tentacles are also contained in the axis of the body, but what their function is in this position remains untold.

Many of the wrecks that appear on our coast bring to us bunches of slender hollow tubes, measuring as much as three or four inches in height, in each of which lived at one time a delicate polyp. Possibly your cluster is still alive, in which case many of the tiny creatures will be seen expanded at the summits of the tubes, their double circle of tentacles spread out in the form of a double coronet (Pl. 4, Fig. 13). Hanging from some of these, like bunches of grapes, are the reproductive buds, which ultimately detach themselves and, medusa-like, swim about in the open sea. It is not generally known that a large number of ordinary jelly-pads or jelly-fishes, whose graceful movements on the oceanic surface have from time immemorial challenged the admiration of the intelligent observer, are the products of tiny fixed colonies such as we have been considering. The discovery of this fact—of the dual existence led by these lower organisms—is one of the most surprising in the entire range of zoological investigation, and one that cannot but carry with it an impressive lesson of the wonderful resources of the world of nature.

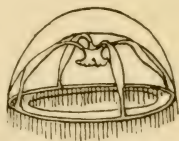
The delicate tubes which in *Tubularia* ensheathe the elongated body-stalk are in a number of forms expanded at their extremities into a cup or bell for the reception of the body of the animal itself. These are the bell-polyps, or campanularians, which grow usually in shrubby clusters, some so small as readily to elude observation, others attaining several inches in length. I am not sure that the bell-polyp proper (*Campanularia*) has ever been officially reported from our coast, but if not yet noticed it will almost surely be found in the near future, and it can but afford pleasure to make a sharp search after it. Examine the piles, the stones, and the sea-weeds, and let not even the grass-covered shells escape you. Its near ally, the *Obelia commissuralis* (Pl. 4, Fig. 11), has already secreted itself among the time-worn timbers of ancient wrecks, where it hangs in bunchy clusters three inches or more in length. It is also found attached to stones and sea-weeds, giving birth at certain seasons to delicate free-swimming medusæ, which may be recognized by their sixteen tentacles.

A second species of *Obelia* (*O. gelatinosa*), differing from the preceding in its compoundly united stems, also finds a favored home among the piles, although it is not infrequently found growing from the surfaces of oyster-shells. One of the most beautiful and abundant of the pile-inhabiting polyps or hydroids, especially where the water is in a measure brackish, is the *Parypha crocea* (Pl. 4, Fig. 5), which "forms large clusters of branching stems, often six inches or more in height, each of which

is surmounted by a beautiful, flower-like, drooping head of a pink or bright red color. These heads are often broken off, or even voluntarily cast off, when the animals are unhealthy, but new ones are soon reproduced, and therefore this does not seem to be a very serious accident, though certainly a very inconvenient one, for the mouth, stomach, tentacles, and most other organs are all lost when these heads drop off" (Verrill). As in *Tubularia*, the reproductive buds hang down in drooping (red) grape-like clusters, but they do not develop into free medusæ.

JELLY-PADS AND JELLY-FISHES.

The favored few among the 'dwellers by the sea' to whom a bright and warm summer's day is something more than a source of unmitigated discomfort and complaint cannot easily pass a more delightful hour than by navigating the quiet waters in search of medusæ. These exquisite creatures, for all the world like water-bubbles, will almost surely be out in greater or less number; but some of them are so minute, almost microscopic, others so transparent, that, unless the sea is actually covered by them, a sharp watch must be kept, or else they will escape us. A glass jar will be of service in a trip of this kind, as through its aid a *rapprochement* may be effected between us and the tiny creatures whose habits we wish to study. Some appear nearly torpid on the surface, dragging their tentacles wearily



MEDUSA.

after them ; others, again, are darting actively along, propelled by successive pulsations of their transparent bells. It is at first difficult to conceive that these delicate films are indeed masses of organized animal matter, so frail and evanescent do they appear as they noiselessly slip by. But scoop up a *Clytia*, or a *Dactylometra* (Pl. 4, Fig. 6), and examine the animal leisurely in the jar that has been brought for that purpose. Structures that escaped our attention before are now distinctly visible. The pulsating bell is the first object to attract our notice. Its perfect transparency permits us to see, suspended from the centre of the interior, a peculiar pouch-like body, at the extremity of which is situated the mouth. The water entering by the mouth passes into the hollow of the pouch or manubrium, whence it is in great part distributed to the four radiating canals which descend the sides of the bell to its base and divide it into four equal parts. These vessels, which constitute a part of the circulatory system of the animal, merge into a common marginal ring which surrounds the base of the bell. From this ring are given off a number of long processes, known as tentacles, each of which is provided with the very remarkable stinging nettle- or lasso-cells to which reference has been made in our description of *Pennaria*.

This, then, is the substance of our medusa—a quantity of water encased in a thin film of animal matter. Place your finger gently on the bell, and you will probably be unable to detect its presence there. Take the animal from the water and expose it to

the sun, and in a short time it will have almost completely disappeared through evaporation. Whence came these singular creatures, and whither do they go? The greater number of them begin life in a quiet way as minute buds on the stems of the campanularians and their allies. After expanding and acquiring definite shape they drop off from the parent, and pass into that stage which fits them for a free existence on the oceanic surface. The medusa thus formed for some time leads the life of an independent rover, but after a certain period it gives birth from eggs to elongate tiny bodies, known as planulæ, which soon attach themselves and grow up into the grandparental form of the hydroid colony. Thus a complete cycle of changes is brought about. Some of the medusæ give birth directly to other medusæ, without passing through any of the intermediate conditions that have just been noted.

The transition from the delicate sea-bubbles, whose existence, it would seem, could be wiped out by a mere blow of the breath, to the large unsightly jelly-pads that lie scattered over the shore after high-water, is an abrupt one, but yet the two objects are much the same thing. One is merely a large jelly-fish, while the other is a small one. But on the open sea even the large *Cyanea*, whose disk or bell measures two yards in diameter, and whose wilderness of tentacles floats out to a distance of a hundred feet or more, is a beautiful object, reflecting its brilliant tints of pink, yellow, blue, and brown to striking advantage. When cast on the

shore lifeless and tentacleless, deformed and decaying, it cannot but present a more or less repulsive appearance, and it is little wonder that, from what is generally their first experience, most people want to have little to do with jelly-fishes. In the case of the *Cyanea* this aversion has much in its favor, since the animal is a powerful stinger, and can inflict injury that few would like to have repeated.

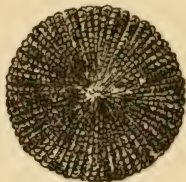
The *Cyanea arctica*, which is the largest form of jelly-fish known, is one of the commonest of the Atlantic coast species, and some of its ill-shaped pads can at almost all times be found upon the shore. About equally common is the 'sun-jelly,' or *Aurelia* (Pl. 4, Fig. 1), whose disk, however, rarely measures more than fifteen inches across. Both species are the product of tiny attached hydroids measuring less than an inch in length.

Among the rarer species of jelly-fish occurring on the New Jersey coast is the Portuguese-Man-of-War (*Physalia*), which is wafted thither from the southern waters on the current of the Gulf Stream. In this species of remarkable form and exquisite coloring we have a compound colony of free-swimming hydroids and attached medusæ, all united, as it were, under a single roof—the large swimming bell or float. Equally rare are the closely-related *Velella* (Pl. 4, Fig. 9) and *Porpita*, although the disks of the latter, particularly in the southern parts of the State, have been thrown up by hundreds as the result of a single storm. A small round jelly-fish, of much the size and appear-

ance of a gooseberry, but of an exquisitely delicate structure, is occasionally thrown on our shores. It is the *Pleurobrachia rhododactyla*, the type of a group known as the comb-bearers (*Ctenophora*), which differ in some essential



PORTUGUESE-MAN-OF-WAR.
(after Tenney.)



PORPITA.

points of structure from the normal jelly-fishes.

Probably all jelly-fishes are phosphorescent, and



PLEUROBRACHIA.

the glow of golden light which they emit constitutes one of the splendors of the oceanic waste.

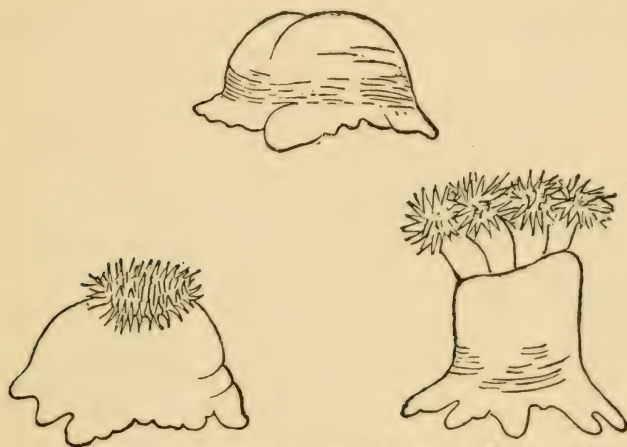
From far and near, if the sea be agitated, the mellow lights may be observed to illumine the enveloping darkness, while along the surf-bound coast

a continuous fiery crest is apt to mark the action of the breakers. At other times, in a quiet sea, there may be but little luminosity, unless the water is stirred up by the passage of a boat or the dip of an oar, when the scattered golden drops appear as though cast in metal. How much of the phosphorescence of the sea is produced by these creatures alone still remains to be determined, but that they contribute very largely to the phenomenon there can be no doubt.

SEA-ANEMONES.

In her charming description of the animals of Massachusetts Bay Mrs. Agassiz says, "Nothing can be more unprepossessing than a sea-anemone when contracted. A mere lump of brown or whitish jelly, it lies like a lifeless thing on the rock to which it clings, and it is difficult to believe that it has an elaborate and exceedingly delicate internal organization, or will ever expand into such grace and beauty as really to deserve the name of the flower after which it has been called." And such is the truth. Only when the animal has again expanded, and thrown out its crown of delicate feelers or tentacles, are we placed in a position to appreciate fully the beauty and grace of the flower of the sea. The rock-bound tidal pools and grottos are the favored haunts of the sea-anemone, whose variously-tinted bodies of orange, purple, pink, and white, placed in relief against the sombre walls, produce an effect rivalling that of the artist's palette. On our shores, unfortunately, the absence

of favoring conditions prevents the development of these interesting animals, which only at comparatively rare intervals may be picked up adhering to sheltered pieces of timber or to rocks that have been cast into the sea. One of the species occurring with us is of about the size of a carrot or a turnip (*Actinia rapiformis*), of a pink or light flesh color, and with a compound cluster of coarse ten-



ANEMONE IN DIFFERENT STAGES OF EXTENSION (after Agassiz).

tacles. The bands that are seen to run up and down and across the body are the muscular bundles which promote expansion or contraction on the part of the animal. When cast up by the waves the animal frequently draws itself into a more or less globular form, which has been likened to that of an onion or a turnip. A much more delicate, and apparently rarer, species is the common form of

the New England shores, *Metridium marginatum*, whose rich and varied coloring of pink, chestnut, white, orange, yellow, and brown stamps it as one of the gems of the sea.

The sea-anemones are next of kin to the hydroids and jelly-fishes, and, like them, their plan of structure is that of the radiate type. Properly to understand the organization of these animals you have but to imagine a cylindrical tube, closed at the bottom, and tucked back upon itself on top in such a manner as to make a tube within a tube, precisely as the finger of a glove is pulled within itself when it does not readily leave the hand. The smaller inner tube of the Actinia, which constitutes the stomach proper of the animal, communicates with the outer world by means of the upper opening, the mouth, while it empties below into the general body-cavity of the animal. This body-cavity, into which sea-water freely penetrates, is divided by a number of vertical partitions into as many distinct chambers, from which, as outgrowths, arise the hollow tentacles. This practically represents the sum total of the organization of a sea-anemone. Were we now to cut one of these animals transversely across the body, we should find an inner circle within an outer one, and the two connected by a number of radiating walls or partitions.

The majority of the sea-anemones attach themselves firmly by means of a stout muscular disk, whose tight hold secures the animal against the wash of the sea. A few are free-swimming on the

surface of the ocean, while still others bury themselves to considerable depths in the sand and mud. The beautiful *Cerianthus*, whose purple-tentacled crowns recall the asters of our meadows, is an abundant form of the southern sand-shallows, which in the north is replaced by the singular worm-like and mud-inhabiting *Halcampa*. Like all other sea-anemones, the *Halcampa* is an exceedingly voracious animal, and, if unguardedly placed in a vial of sea-water containing marine worms and like treasures of the shore, will without compunction almost immediately begin a meal. And it is wonderful to what an extent their meal may be drawn out.

Another sand-inhabiting form, frequently found attached to the under surfaces of stones, is *Sagartia leucolena*, also known as the 'white-armed anemone.' It is a much less slender species than the preceding, and differs in addition in the greater number and length of its tentacles.

These animals multiply from eggs, by budding, and by fission—*i.e.*, by constriction and subsequent separation of the body into two or more parts. The latter process is repeated among many corals, although in the greater number of cases their compound colonies are built up through continuous budding. If you can conceive of a budded or compound colony of sea-anemones with the individual animals reduced in



HALCAMPÆ.

size to the dimensions of small polyps, and each individual polyp secreting for itself an outer covering of lime and an inner series of lime partitions (septa) corresponding to the fleshy ones that have been described, you have before you the structure of a true coral, such as we find among the great reefs of tropical waters. A single species (*Astrangia astræformis*), which forms encrusting colonies on stone or shell from one to three inches across, is found on our northern coast, and has been occasionally picked up on the New Jersey shores.

III.

STAR-FISHES, SEA-URCHINS, AND SEA-CUCUMBERS.

It is not often that one has the pleasure of meeting with star-fishes on the New Jersey coast, but yet they are occasionally seen, perhaps more frequently in the north, and thus they deserve a place here. The commoner form (*Asterias berylinus*, Pl. 5, Fig. 3) is a fairly large species, of a more or less greenish color, sometimes inclining to brown, and roughly covered with tubercles. Its five arms, at the extremity of each of which is situated a single red eye-speck, are somewhat irregularly disposed, and not rarely one is stumpy through breakage or unequal development.

It is interesting to watch the movements of the star-fish. From the under surfaces of the arms, at whose union is situated the central mouth, a great number of delicate tubules, each one terminated by a minute sucking-disk, may be seen to be vigorously in motion, the whole series undulating like wind-swept grain. These tubules are hollow and fed from within with sea-water, the increase or diminution of which within the tubules, regulated at the will of the animal, determines the length to which they may be extended or protruded. Attaching themselves to foreign objects by means of their sucking-disks, the animal may in this way be

either drawn forward, or the object of its search drawn to it. The system of vessels which supplies the tubules with water, governing as it does the walking apparatus of tube-feet, is known as the 'ambulacral' system. The area, again, along which the tube-feet (ambulacra) are placed has been called the ambulacral zone, and the intermediate spaces—the sides and backs of the arms—the inter-ambulacral. On the back of the animal, a little sub-central, and in the angle between two of the arms, is a tumid little body, of a bright orange color, called the 'madreporic tubercle,' through which the sea-water gains access to the ambulacral system of vessels.

Star-fishes are voracious animals, and they have a method of securing their food which is at once novel, and, to say the least, effective. Seizing their prey, which consists largely of shell-fish, they arch themselves over it, turn their stomachs inside out, so as completely to envelop the delicate morsel, and then deliberately proceed to make a meal. On some of our northern coasts the star-fish is the principal enemy of the oyster and scallop, vast quantities of the former being annually gobbled up by this five-armed demon. According to the reports of fishermen the appearance of the star-fishes on the coast is frequently dependent upon the earlier appearance there of the scallop. Star-fishes are very tenacious of life, and they will bear much injury without succumbing. Indeed, each individual ray, when torn from the body, has the power of reproducing the entire animal.

The brittle-stars, or, as some choose to call them, feather-stars (Pl. 5, Fig. 5), are closely related to the star-fishes, differing mainly in that the arms radiate from a clearly-defined central disk, and, being more nearly solid, do not contain prolongations of the stomach or of the ovaries in their interiors. The tube-feet pass out from the plates along the sides of the arms, instead of from the under surface as in the star-fishes proper.

The brittle-stars are fairly active creatures, helping themselves rapidly over the sands by means of their long flexible arms. Their home is largely among the tangle and eel-grass, where their protective coloring affords them a safe harbor.

SEA-EGGS AND SAND-DOLLARS.

Most visitors to the sea are acquainted with the appearance, at least, of the 'sand-dollar' (or 'sand-cake,' as it is sometimes termed)—a thin shelly piece, from an inch and a half to three inches across, with a peculiar stellate ornamentation on one side, and irregular grooves and channels on the other. It immediately suggests a relationship with the star-fishes through its well-made star, although in a general way it appears to be a very different animal. Many people, indeed, scout the idea when informed that an animal inhabits this frail habitation, so unaccommodating does it appear; but an animal dwells within it nevertheless, and this animal is truly a near relation to the star-fish.

In its living condition, or when freshly removed from the water, the sand-dollar (*Echinarachnius*, Pl.

5, Fig. 2) is of a reddish-brown color, and completely covered over with minute silken bristles. These, on the death of the animal, are rapidly removed, and then the flat disk can be plainly seen to be made up of a large number of closely-fitting polygonal plates, arranged in twenty series around the circumference. The petals of the central star, which now becomes visible, will be found to be made up of transverse slits, and if the direction of the petals is followed to the border of the disk, it will be seen that the slits are continued by pores. Through these slits and pores, which occupy five pairs of plates, the tube-feet, similar in character to those of the star-fish, pass out, and hence define ambulacral zones. The intermediate five pairs of plates, from which pores are absent, will then be the interambulacral areas. Now, imagine the arms of a star-fish turned over the back of the animal so as to have the tips meet, the animal then flattened out, and the sides of the arms so expanded as to close in the interspaces: you would then have a construction much as in the sand-dollar and in other sea-urchins. This appears really to be the relation, but just how the diverging modification has been brought about still remains to be determined. The eye-specks, which in the star-fish are placed at the extremities of the arms, are in the urchin situated centrally on top, or just where we should expect to find them on the assumption above stated.

Alternating with the eye-specks are the ovarian apertures, through which the eggs are passed out from the body. In the cluster of small plates which

form the apical disk is also situated the madreporic tubercle. The entire surface of the shell, seen to better advantage in a second species of our coast, the sea-egg (*Strongylocentrotus*, Pl. 5, Fig. 4), bristles with spines, between which rise the very delicate tube-feet, swaying to and fro in search of objects to be placed within their grasp. The sea-urchins like to conceal themselves, and they will thus frequently cover their habitations with seaweed, grass, pebbles, and shell-fragments. In this condition they can be readily passed over without being noticed by their enemies. A southern species when placed in a bucket of gravel and shell will almost immediately disappear beneath the surface, lifting the material over its back. Progression is effected almost exclusively by means of the tube-feet.

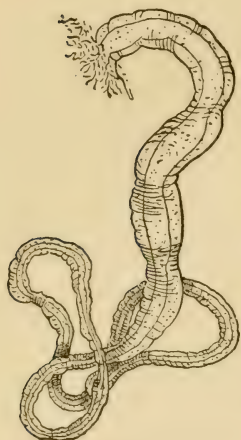
Two other species of sea-urchin occur on our coast—one, the purple sea-urchin (*Arbacia punctulata*, Pl. 5, Fig. 6), a convex form, readily distinguishable by its comparatively stout and purple spines; and the other, the sand-cake proper (*Mellita quinquefora*, Pl. 5, Fig. 1), a flattened species much like the sand-dollar, easily recognized by the five slits in its shell.

It would scarcely be proper to complete our notice of these interesting animals without calling attention to their peculiar five-toothed masticatory apparatus and to the singular bird-beaked bodies—pedicellariæ—which rise up between the spines. The full function of the latter has not yet been ascertained, but that they in part assist in removing

obstructions from the surface of the test, where this is necessary, can be easily seen.

SEA-CUCUMBERS.

The sea-cucumbers, or holothurians, constitute an interesting group of animals whose members live both upon the rocks and buried in the sand or mud.



SYNAPTA.

Although so different in general appearance, they represent only extreme modifications of the structure seen in the star-fish or the sea-urchin. Take for example that singularly attractive creature the *Synapta*, whose elongated leech-like body can be secured from the mud-flats by the aid of a garden-trowel, and examine it. The transparent cylindrical form, permitting the yellow intestinal canal to be clearly visible in the interior, shows at first little to

connect it with either star-fish or sea-urchin, but soon you will perceive five well-defined bands traversing the length of the body from one extremity to the other. These are indeed the ambulacra, although in this instance the tubes are closed and, so far as locomotion is concerned, functionless. In its fundamental structure, therefore, the sea-cucumber is only a greatly elongated sea-urchin, being pushed out axially, as it were, to its

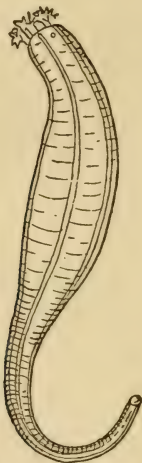
farthest limit. But it differs in many details of structure. The mouth in the *Synapta* is surrounded by a wreath of branched tentacles, into whose interior the sea-water is admitted through a system of vessels connecting with a madreporic tubercle. The latter structure, as in all other sea-cucumbers, is placed near the mouth.

Closely examined, the transparent wall of the body will be found to be speckled with minute wart-like processes, giving the animal a rough feel when taken in the hand. These processes under a microscope reveal most extraordinary forms, which are most nearly likened in outline to an anchor: hence we speak of the anchor-like spicules embedded in the body-substance, which of themselves frequently offer good characters in the determination of species. In some forms, as in the remarkable pangolin-like *Psolus* of the New England coast, these processes, or rather their representatives, are developed into an armor of stout overlapping scales or plates.

Placed in a dish of sea-water, the habits of this interesting creature can be studied at leisure, the regular rhythmic or wave-like motion of the body proving a never-failing source of surprise to those to whom the animal is a novelty. At some moments it has contracted into a nearly perfect ball, at other times it has straightened itself to double its usual length. Frequently it throws off parts of the posterior end of its body, accomplishing this curious freak either by close constriction, or by the forcible expulsion of its intestines. In feeding, the

Synapta takes in large quantities of fine pebbles, sand, and shell, from which it doubtless extracts considerable nourishment. These objects are distinctly visible through the walls of the body and intestine.

A much stouter form of the sands is the Caudina,



CAUDINA ARENARIA.

which is sometimes thrown up in considerable numbers after a storm. Its color is light yellowish, the texture is tough, and in a distant way the animal might be likened to a cucumber greatly attenuated at one extremity.

IV.

OUR CARCINOLOGICAL FRIENDS.

AMONG our first acquaintances of the sea-shore are sure to be a number of those merry sprites which have not yet mastered the lesson of how to walk straight—or rather, we should say, walk straight ahead, for if many of the crabs have failed to acquire the habit of following in the direction towards which the head points, they have well acquired the art of diverging straight from it at a right angle. It is certainly one of the most interesting sights of the shore to observe these apparently one-sided creatures hurrying off in their lateral progression, making probably for their burrows in the sand or mud; pass them, and note how rapidly some of them reverse their motion, without even so much as stopping to glance at their pursuer. The machinery appears to have given out at one end, when they immediately reverse, and travel back over their old course. Among the more pronounced offenders against the commonly accepted law of proper walking are the little ‘fiddlers,’ or ‘calling crabs’ as they are sometimes termed. Their burrows, indicated by holes about as large as would be made by a thrust from an umbrella-point, are scattered all over the salt marshes and mud-flats at about high-water mark, and from

them you can frequently see the little animal peeping forth, preparatory to a sally. At another part of the flat, where the thud of your footsteps has not given advance signals of danger, hundreds of these merry crabblings are probably busily occupied with their out-door labors. Approach them, and away they scamper to their habitations. There are both males and females in the throng, the for-



FIDDLER (*Gelasimus vocator*)

mer recognizable by the very undue development of one of the claws, which is carried transversely in front of the head. When provoked, the animal brandishes this claw in a somewhat threatening manner, which has been likened to the pulling of a violin-bow—hence the name of ‘fiddler’—and by others to the action of beckoning or calling (hence ‘calling crabs’).

Taking the necessary precaution to hold the big

claw, examine somewhat more closely one of these animals. Observe the two bead-like compound eyes, supported on long stalks, which can be readily withdrawn into the protecting shield of the carapace. The manner of this support, allowing of vision in almost every direction, has given to the group in which this structure is found the name of the stalk-eyed crustaceans, to which, in addition, the lobsters, crayfishes, hermits, and shrimps, etc., belong. The two pairs of feelers in front of the eyes, known as antennæ and antennules, are of peculiar interest as examples of combined organs, for, apart from acting in their capacity as feelers alone, they seem to subserve the functions of smelling and hearing, the auditory apparatus being lodged in the base of the smaller pair. The feet are ten in number, a feature distinctive of the so-called ten-footed or decapod crustaceans. At first sight a crab appears to have no tail, but if the animal is turned over on its back, the tail—it is true, a comparatively short one—will be seen to be safely tucked under the body. If we take by way of comparison in our studies a lobster or a crayfish, we soon perceive that there is an entirely different disposition of this part of the body—that the tail, or more properly the abdomen, is stretched out beyond the body proper, and that it is greatly elongated in relation to the length of the animal. We thus recognize two distinct groups of ten-legged stalk-eyed crustaceans: the short-tailed forms, or crabs (*Brachyura*), and the opposite or long-tailed forms, such as the lobster,

the shrimp, etc. (Macrura). An intermediate type is represented by the hermit-crabs, with some of whose habits we have already become acquainted.

There are two species of fiddler found on our coast, much resembling one another in both color and ornamentation. The more common form (*Gelasimus vocator*) has a smooth and shining carapace, whereas in the second (*Gelasimus minax*) the carapace is minutely granulated and in part tuberculated; in both the back appears impressed with a figure much like that of the letter H.

The second species, which appears to be a vegetable feeder, is much the larger of the two, and its burrows are not infrequently one and a half inches across, or even more. It inhabits the estuarine region, in immediate proximity to fresh water, rather than the tidal flats, and, indeed, it appears to be able to get along for weeks, or even months, without absolutely requiring salt water.

In excavating, the fiddlers throw or push up the pellets of moist earth by means of their anterior walking legs, depositing their burden usually at some little distance from the mouth of the burrow. At the approach of winter they close up the domiciliary apertures, and pass into a condition of torpidity until the advent of spring.

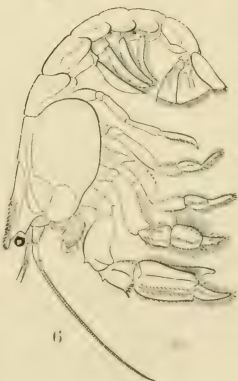
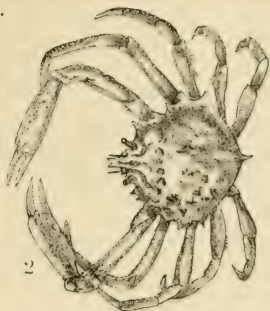
Leaving to their capers the noiseless musicians of the shore, let us examine somewhat more closely the forms that nature has fashioned with a little nearer approach to symmetry. The 'regular' crabs, in a general way, look very much alike, differing seemingly only in the proportion of parts



PLATE 6.

FIG.

1. *Cancer irroratus*.
2. *Libinia canaliculata*.
3. *Carcinus mœnas*.
4. *Callinectes hastatus*.
5. *Platyonichus ocellatus*.
6. *Gebia affinis*.



and ornamentation. This is, however, a false conception, for they differ among themselves not only in important structural characters, but largely also in habit. Some are habitually walkers of the sand, others burrowers in the mud, a few parasitic on different animals, and others, again, good swimmers. A number use the floating sea-weed for their home, drifting far into mid-ocean. The famous Sargasso Sea is a carcinological world of itself. Down to a depth of several thousand feet in the sea the lonely crab lurks about in the darkness, finding companionship with the mollusks whose shells it frequently robs. Again, on mountain-heights of 4000 feet elevation or more the land-crab (*Birgo*) is not uncommonly met with on its travels.

Look at the extremities of the last pair of legs of the soft-shell crab (Pl. 6, Fig. 4)—the crab *par excellence* of the Atlantic coast—and compare them with the similar parts of the spotted or sand-crab (*Cancer irroratus*, Pl. 6, Fig. 1), the common transverse species, whose empty ‘boxes’ are to be found at almost all times on the beach. In this species, which can be readily recognized by the nine blunt teeth projecting from each side of the anterior edge of the carapace, they are merely pointed blades, but in the soft-shell, the edible form, they are flattened out into paddles, forming efficient swimming organs. The soft-shell (*Callinectes hastatus*) is thus the type of a group of swimming crabs, of which the beautiful ‘lady’s crab’ (*Platyonichus ocellatus*, Pl. 6, Fig. 5) is another representative. It is not to be assumed that these swimmers constantly float on

the ambient waters, for they appear to delight in the mud-flats as much as the other species; but they possess, in the art of swimming, one advantage over their fellows.

When the embryo crab escapes from the egg it is liberated in the form of a very remarkable little body known as the Zoea, whose real nature was for



ZOEAL OF CRAB (magnified).



MEGALOPS (magnified).

a long time a sealed chapter to the naturalist. This Zoea is furnished with a big head and an elongated body, but the features that most readily arrest one's attention are the three or four long spines which appear to be carelessly thrust out from different parts of the body and head, and which give to the tiny creature a singularly uncouth aspect. For many years before the connection between the Zoea and the crab was known, the former was looked upon as a mature animal, and naturally regarded as a distinct species. From the Zoea the crab passes by gradual stages to the Megalops condition, when, as the name indicates, the eyes are developed to a disproportionately large size. In this process of growth to maturity the crab is compelled at repeated intervals to cast its skin or shell,

so that it may acquire a new one conformable to its progressive stature. This process of sloughing the shell appears to take place annually; the length of time required for its full accomplishment—i.e., from the moment of the throwing off of the old shell to the proper cementing of the new—being in the neighborhood of forty-eight hours. In this interval the crab is known as a ‘soft-shell’ or ‘shedder,’ in which condition it is by many highly prized as an article of food.

The common edible crab or ‘blue crab’ delights in the sheltered muddy shores of coves and bays, and in the brackish waters of estuaries, where it can be frequently seen in numbers swimming up and down with the advancing and retreating waters. The young, more particularly, frequent the tangle of shore-line grass and weed, whence in case of alarm they swim out to deep water. The food of this species consists largely of fishes, certain forms of which, in turn, destroy great quantities of the crabs.

Two interesting hole-inhabiting crabs somewhat related to the fiddlers, but with nearly equally developed claws, are *Sesarma reticulata* and *Ocypoda arenaria*. The latter, which is also sometimes known as the ‘sand-crab,’ is interesting from the close approximation of its coloring to that of the sand in which it dwells—an instance of true protective resemblance. It is carnivorous in habit, and is said to spring upon the beach-fleas much as a cat springs upon mice.

There are two species of so-called ‘oyster crab’ on our coast, which possess widely different habits.

One of these, a yellow-brown species whose carapace measures about an inch across, partakes somewhat of the character of the fiddlers in having the claws unequally developed, but the large claw is carried in the normal way and without the threatening exercise of the fiddler. The species, also known as 'mud-crab' (*Panopeus Herbsti*), is an *habitué* of the oyster-beds, where it is said to destroy large quantities of the oyster spawn. The second species (*Pinnotheres ostreum*) is a much smaller form, not



PINNOTHERES.

measuring more than a half-inch in either length or width, and is habitually associated with the oyster within the latter's shell.

A few words about that forbidding-looking creature the sea-spider (Pl. 6, Fig. 2). This crab, of seemingly morose habits, lacks the vivacity of the other species. It is a somewhat rare visitor to the open shore, preferring the quiet of the deeper waters, where, in apparent meditation, it leisurely walks over the encumbrances that may be placed in its path. It seems to shun observation, and frequently allows itself to be overgrown by plants of various kinds, hydroids, etc., which completely mask its identity. Although by strangers usually given a wide berth on account of the long claws, the animal is but a feeble representative of a group whose members in other parts of the world are giants in comparison. A specimen of the Japanese *Macrocheira* in the possession of the British Museum measures some eighteen feet in expanse of legs.

HERMIT-CRABS.

These sprightly little animals, which are usually of small size, are a source of never-failing delight to the student of nature. They have truly habits of their own, which stamp them at once as being original and distinctive. It is well known that the 'hermits' derive their name from the seclusion into which they cast themselves as inhabitants of the shells of other animals, but it is probably not so generally known that the rights of tenantry are frequently exercised in a very arbitrary manner. Thus, the hermit-crab is not always satisfied in the choice of a dead shell, but will raid upon a living possessor and attempt to drag it from its stronghold; and in this operation the assailant will frequently receive the assistance of a number of its fellows, each one carrying his castle as defensive armor. It is true that the attack is probably in many cases made for the double purpose of obtaining the enemy as well as its belongings; but, however this may be, forcible possession is by them considered to be no misdemeanor.

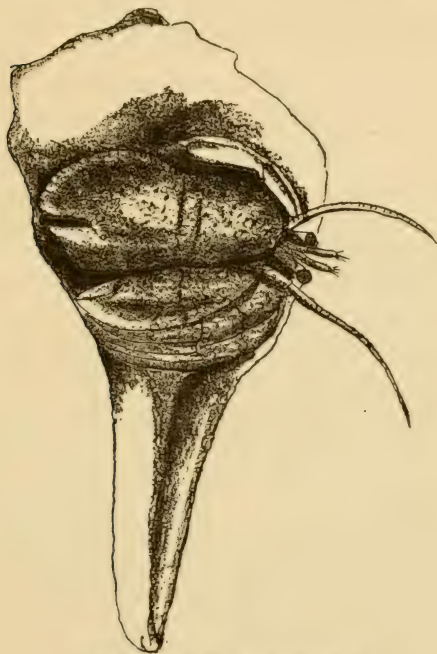
In the greater number of the hermit-crabs the body is unprotected by a carapace, and, being soft and liable to injury, the animal seeks protection under cover usually of a snail-shell, winding itself about the coils of the shell, to the inner extremity of which it attaches itself by means of its modified posterior feet. In this position the animal is only with difficulty withdrawn, retracting itself farther and farther within cover of the shell. A sudden

fracture of the apex of the shell, under which appears to be the most delicate part of the animal's body, will generally effect an immédiate dislodgement, the terrified crab dropping from the aperture. With its progressive development in size the hermit requires frequent changes of abode, and its methods in securing a new habitation are among the most interesting of the special habits acquired by animals. The creature is very circumspect, and will make several reconnoissances before he feels fully satisfied with the size, manner, etc., of a prospective habitation, retiring after each visit to the old shell. The Rev. Mr. Lockwood thus graphically describes the line of operations involved in house-hunting :

“ But the hermit grows, while the shell which he occupies does not. Hence, like many bipeds, he has his first of May, so he goes house-hunting. This must be understood literally. He finds a shell. Will it do ? First, then, is it really to let ? He will inquire within. This he does, if not most courteously, very feelingly. Satisfied on this point, the next question is, will the house suit ? He turns it over, then turns it round. You see, the weight of one's house is quite an item in the reckoning to him who has to carry it on his back. One inspection more. How is it inside ? Is it certainly empty and of the right size ? Up goes one of the slender limbs of the second pair, and the interior is thoroughly explored. All right ! Just the house he is after. His mind is made up to move. Look at him ! Quick ! or you will miss it ! Out comes the

body from the old house, and pop it goes into the new one. The resolution to move was taken, the surrender of the old house was made, and the occupancy of the new was effected, and all within a fraction of a second of time.

“Sometimes this matter goes on less pleasantly.



‘WARTY HERMIT’ IN PEAR-CONCH.

Two house-hunters may find the same tenement. Should both desire it, then comes the tug of war. Live together they neither can nor will. The affair is settled by a battle, in which the stronger proves

his claim right by the Carlyleian logic and morals, viz., might. Quite often from these encounters a terrible mutilation results. To us it is a sad sight to see the little hermit when his time has come, and he knows it; that is, when *Eupagurus* must die. However droll his career may have been, the little hermit is grave then. And what a strange fact it is! Who can explain it? The poor little fellow comes out of his house to die. Yes, in order to die. To us humans home is the only right place to die in. But for *Eupagurus* home has no attractions at this solemn time. Poor fellow! with a sad look and melancholy movement he of his own will quits the house for which he fought so well. Those antennæ, or feelers; that often stood out so provokingly and were so often poked into everybody's business, now lie prone and harmless. The eyes have lost their pertness. There lies the houseless hermit on that mossy rock, stone dead."

The two species of hermit occurring on our coast can be readily distinguished from each other by



LITTLE HERMIT (*Eupagurus longicarpus*).

their size and the difference in the shape of the big claw. The 'warty hermit' (*Eupagurus pollicaris*), the larger species, inhabits the shells of the big Naticas and the Fulgurs, and can be immediately recognized by its coarse broad claws,

which in great part close up the aperture of the

shell occupied by it. In the more common form of the small shells (*Eupagurus longicarpus*), which rarely attains a length much exceeding one inch, the legs are all much elongated, giving the animal a very slender appearance.

SHRIMPS AND PRAWNS.

Of the long-tailed ten-footed crustaceans (*Macrura*) the best-known representatives are the lobster, shrimp, and prawn. The first, which is too familiar to require special notice, can scarcely be considered to be a true member of the New Jersey coast fauna, having been introduced with the building of the Delaware breakwater, where it has secured somewhat of a permanent footing. Its rarity otherwise must be attributed to the absence of an environment suited to its living and development. The rocky shores of the North constitute its true home, and although stray individuals are found farther south, they rarely appear below the East River. The species sometimes attains an enormous size, individuals frequently weighing as much as fifteen to twenty pounds, and occasionally passing much beyond this limit. An animal somewhat resembling the lobster, although considerably smaller in size—measuring only three or four inches in length—is the *Gebia affinis* (Pl. 6, Fig. 6), a profound burrower of the mud-flats.

The shrimps and prawns, which much resemble one another, are abundant in the bays and harbors, passing up to considerable distances in the tidal streams and creeks. They are active little creatures,

of a light-green color, or nearly colorless, and often quite translucent. In this country they are not so highly esteemed as an article of food as they are in either England or France, where the prawn-fishery constitutes an important branch of industry. Our common shrimp (*Crangon vulgaris*, Pl. 7, Fig. 8), which can be distinguished from the prawn (*Palæmon*, Pl. 7, Fig. 9) by the terminal joints of the two anterior pairs of legs being undivided, and by the filiform structure of the succeeding legs, does not appear to differ from the ordinary European species. It is abundant in the waters of the sandy



PANDALUS.

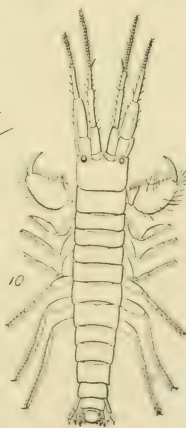
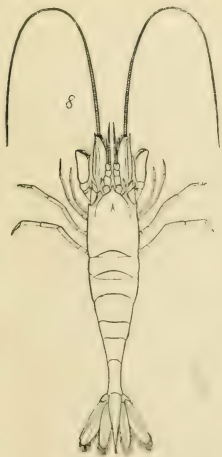
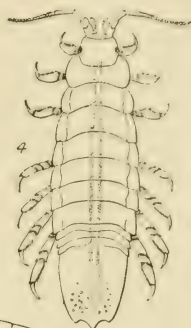
flats, where by reason of its harmonizing coloring it escapes ready detection. Both shrimps and prawns are frequently infested with a loathsome parasite, which attaches itself as a round black mass on one side of the neck of the victim. This parasite is in itself a crustacean, known to naturalists as *Bopyrus*.

A so-called shrimp, not to be confounded with either of the preceding, is the *Mysis stenolepis* (Pl. 7, Fig. 1), which appears more abundantly about our coasts during the winter months. It may be distinguished from the true shrimps by its cloven or double feet, and by the external position of the gills. From the circumstance of its carrying its eggs in a pouch underneath the thorax it has received the familiar name of 'opossum shrimp,' by which it is generally known.

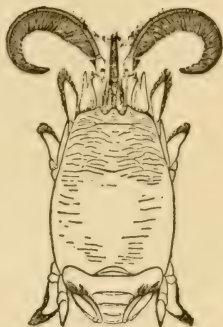
PLATE 7.

FIG.

1. *Mysis stenolepis*.
2. *Limnoria terebrans* ($\times 7$).
3. *Caprella geometrica* ($\times 2\frac{1}{2}$).
4. *Idotea irrorata*.
5. *Gammarus ornatus*.
6. *Orchestia agilis* ($\times 4$).
7. *Amphithoë maculata*.
8. *Crangon vulgaris*.
9. *Palæmon vulgaris*.
10. *Unciola irrorata*.



A common object—indeed, one of the commonest objects of the sands—is the cylindrical mole crab or ‘sand-bug’ (*Hippa emerita*), whose vertical burrows open up in great number, particularly in the lower tidal region. The animal is a remarkably rapid burrower, pushing itself head downward by means of its anterior or thoracic feet. As a rule, but little organic matter is found within the alimentary canal of the mole crab, which appears to subsist largely upon the nutriment extracted from the swallowed sand. It constitutes a favorite article of food with many fishes.



HIPPA EMERITA.

BEACH-FLEAS, HOPPERS, AND SOW-BUGS.

A walk at almost any hour along the sandy beach is sure to stir up a number of the little hopping crustaceans to which the name of ‘beach-flea’ or ‘sand-flea’ has been applied (*Orchestia agilis*, Pl. 7, Fig. 6). They hop up in front of your footsteps, and leave with equal celerity the seat that may have been selected for you, but not until you have turned over the long line of sea-wrack (dried sea-weed) which fronts the ocean at high-water mark can you have any just conception of the multitudes that are here busily engaged in performing the offices of the public scavenger. Decayed and decaying parts of both plants and animals are equally acceptable to

the beach-flea. Examine the legs of one of these animals, and you will observe that they are disposed on either side in two dissimilar series; hence the name of Amphipoda, double-footed, that has been applied to the broad group to which the hopper belongs. Two closely related, but larger, species, of a gray rather than of an olive or brown color, constitute the genus *Talorchestia*.

A form much like the preceding, but with aquatic habits, is found in both salt and fresh waters, largely frequenting the meshes of the rock-weed (*Fucus*). The *Gammarus* (Pl. 7, Fig. 5), for so the animal is known to naturalists, is a helpless creature out of water, shuffling along on its side in a vain endeavor to elude its pursuers or to regain the water. It occurs in vast numbers in favored localities, contributing largely to the food-supply of many of our coast fishes.

Another interesting amphipod of our coast is found abundantly on the surfaces of submarine plants, and also on sponges, where it may be seen moving about in the manner of the ordinary measuring-worms, arching over its body, and advancing alternately the two extremities. From this close resemblance to the progression of the geometer worms it has received the name of *Caprella geometrica* (Pl. 7, Fig. 3):

Of the less attractive group of the sow-bugs, many of whose members, such as the *Bopyrus*, already mentioned, are parasitic on the tissues of other animals, but few forms are likely to come to the notice of the visitor to the sands. One of

these (*Idotea cæca*) is the little creature whose serpentine tracks over the sand have so frequently called forth the query, What animal made them? The species is found all the way from Massachusetts to Florida. A second form (*Stenosoma irrorata*, Pl. 7, Fig. 4), of a deep-purple or sea-green color, will probably be recognized by many as the active spirit of the quieter waters, whose gyrations strongly suggest a scheme of self-imposed perpetual motion. A third species (*Limnoria terebrans*, Pl. 7, Fig. 2) can generally be found only beneath the water-surface, where it attacks almost any timber—piles, piers of bridges, wharves, etc.—that may be brought within its reach. It is asserted that piles lose as much as an inch in diameter annually through the ravages of this pest. Coating with verdigris or creosote, or sheathing with metallic copper, has proved efficacious as a preventive of destruction.

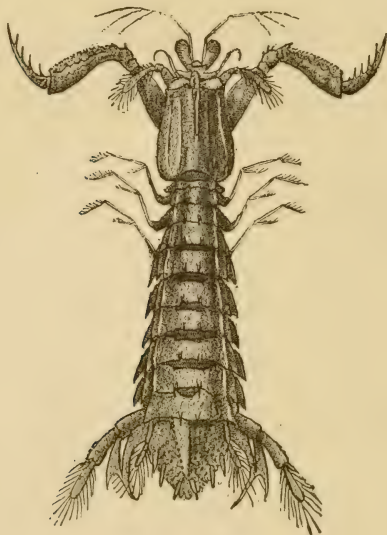
In all these forms the body is largely symmetrical in outline, and the numerous pairs of legs are of nearly equal size and equally disposed along the sides of the body; hence the term Isopoda, equal-footed, that has been applied to the group in general.

SQUILL.

Our description of the Crustacea of the coast would not be complete without reference being made to a somewhat rare species, the squill, which is figured on the following page. The animal can be immediately recognized by its greatly elongated and flattened body, measuring from four to six, or exceptionally ten, inches in length, the great

delicacy of all its ambulatory appendages, except the first pair, and the greatly developed swimmerets of the posterior part of the body. The exterior (?) pair of feelers (antennæ) have also a peculiar structure, being spread out into an oval ciliated plate.

The animal, which is a close relative of a com-

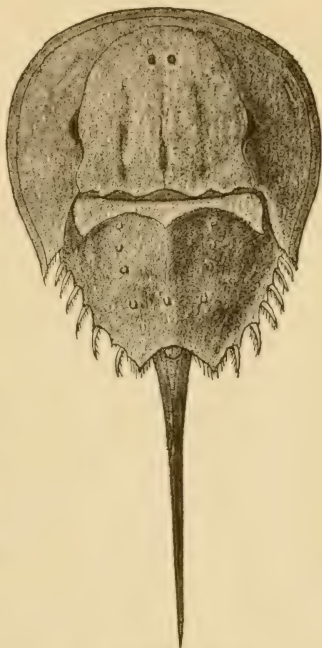


SQUILLA EMPUSA.

mon European species, is in many regions highly esteemed as an article of food. It is a true burrower, but as yet little positive is known of its general habits.

THE HORSESHOE CRAB: IS IT A GIANT SPIDER-FORM?

Those among us to whom the horseshoe crab, or king-crab as it is frequently called, in allusion to its large size, is known only in its general details, would probably scarcely think it worth while to consider the question as to its position in the animal world. What should it be other than the 'crab' that it has always been considered? With our carcinological friends it agrees in the possession of a crusty envelope or shield, it breathes by means of gills, inhabits the water or mud like them, and has, moreover, the end-joints of the legs pincerred (chelate). Further, it periodically sheds its shield like the crabs. But relentless and pursuing science has shown that in many points of structure the animal is closely related to the scorpions, and perhaps even more closely than to the entire group of crust-bearing animals as such (crabs, shrimps, lobsters, etc.). This relation is seen



HORSESHOE CRAB.

in the nature of the walking legs, in the disposition and origin of the nerves supplying the legs, in the structure of the eye, and in the manner of development of the embryo. As against this evidence we have the presence of true gills, and the absence of the peculiar breathing-tubes (tracheæ) of the scorpion; but whether these important points of dissimilarity are of greater value than those of affinity above indicated, must still be considered an open question.

The crust of the horseshoe crab is divided into three distinct parts, an anterior rounded portion, known as the cephalothorax, which protects the more vital elements of the animal's body—mouth, stomach, heart, and legs; a median portion, the abdomen, on the under side of which are the gills, a series of thin plates disposed in the fashion of the leaves of a book; and a greatly elongated spine or tail. The cephalothorax carries on its back two pairs of eyes, of which the two big eyes situated on either side of the shield are compound, while the others, small and placed medially to the front, are simple.

Although it would seem from the general vaulted appearance of the shield that the body of the animal is of considerable thickness, the reverse is actually the case. The under surface of the carapace follows closely upon the inner face of the upper surface, except along the medial region, where the body-space is considerably expanded. In this central part is situated the alimentary tract, the mouth opening between the bases of the second of the

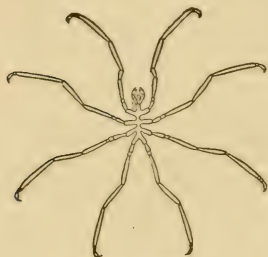
six pairs of legs. The food, which consists of various small animals, largely worms, is conveyed to the mouth by one or more of the foot-pincers, where it is closely rasped and triturated by the rubbing together of the spiny basal joints of the legs.

The horseshoe crab (*Limulus polyphemus*) prefers for its habitat the protected bays and estuarine waters, where it burrows in the sand or mud just sufficiently to cover its body. In this operation of burrowing the head is the excavating organ, while the feet and tail, firmly pressed backward, are the force. When placed on its back the animal has some difficulty in at first righting itself, but by arching upward the carapace, at the same time receiving assistance from the tail, it soon recovers itself.

The horseshoe crab so closely resembles in appearance and structure the ancient trilobites, whose remains are so numerous buried in the older rock-deposits of our earth, that there are strong grounds for concluding that the latter were the true progenitors of the modern race, a conclusion that has been strongly reinforced by the embryological study of the two types. The young *Limulus*, in fact, so nearly resembles the young of certain forms of trilobites as to be barely distinguished from them; at this period the spine is still wanting. Subsequent moulting of the carapace is preceded by a splitting of the latter along its border, the animal drawing itself through the opening thus made.

This species is found abundantly along the coast from Maine to Florida. Where left exposed on

the beach for some time, the gill-sacs are apt to become infiltrated with the sand, when their peculiar accordion-like disposition becomes apparent. When thus distended in irregular rolls they are commonly supposed to represent egg-capsules strung together on a ribbon.



SEA-SPIDER.

Before dismissing the subject of spider forms, it may be well to call attention to the singular slender (eight-legged) creatures that are frequently met with on hydroid colonies and on sponges. From their distinctive forms, and their habit of living in the oceanic waters, they have been named 'sea-spiders' (Pycnogonoids); but their exact relationship has not yet been determined.

THE GOOSE BARNACLE, AND BARNACLES IN GENERAL.

Of the remarkable traditions which have invested the life-histories of many of our animals none is perhaps more indicative of a fertile imagination than that which ascribes to the barnacle the power of giving birth to a fowl (barnacle goose). How such a notion could ever have attained currency, and met with a firm acquiescence on the part of scholars of even a high degree of learning and intelligence, is almost inconceivable. Yet we have not only acknowledgment of a full belief in this miracle, but positive assurances from otherwise re-

spectable eye-witnesses as to the exact stages by which the miracle was accomplished. And even to-day some people, with child-like simplicity, ask if there exists any connection between the two animals.

The following passages from "The Herball or Generall Historie of Plantes," a voluminous treatise of 1500 pages by John Gerarde (edition of 1636), may prove interesting in this connection: ". . . we are arrived at the end of our History; thinking it not impertinent to the conclusion of the same, to end with one of the marvels of this land (we may say of the World). The history whereof to set forth according to the worthinesse and raritie thereof, would not only require a large and peculiar volume, but also a deeper search into the bowels of Nature, than my intended purpose will suffer me to wade into, my sufficiencie also considered; . . . in the meane space take it as it falleth out, the naked and bare truth, though unpolished. There are found in the North parts of Scotland and the islands adiacent, called Orchades, certaine trees whereon do grow certaine shells of a white colour tending to russet, wherein are contained little living creatures; which shells in time of maturity doe open, and out of them grow those little living things, which falling into the water do become fowles, which we call Barnacles; in the North of England, brant Geese; and in Lancashire, tree Geese; but the other that do fall upon the land perish and come to nothing. . . .

"But what our eyes have seene, and hands have

touched we shall declare . . . when it is perfectly formed the shell gapeth open, and the first thing that appeareth is the foresaid lace or string; next come the legs of the bird hanging out, and as it groweth greater it openeth the shell by degrees, till at length it is all come forth, and hangeth only by the bill: in short space after it commeth to full maturity, and falleth into the sea, where it gathereth feathers, and groweth to a fowle bigger than a Mallard, and lesser than a Goose. . . .”

The goose barnacles are common objects about the shore, being thrown up in bunches along with



GOOSE BARNACLE.

the foreign bodies to which they are generally found attached. They locate themselves on piles, below the water-line, to the bottoms of ships, to drift-wood, sea-weed, floating fruit, and, indeed, to almost any object that comes in their way. The peduncle or stalk upon which the encased body of the animal is supported has its origin in one of the

pairs of larval feelers or antennæ, which through modification and additional deposition of matter undergo such transformation as to permit of the new function to which they are now applied. The shell, or ‘capitulum,’ consists of five pieces, four lateral and one marginal (the keel or carina). On the margin opposite to the keel it is open, permitting of the extrusion of the six pairs of (double) long, feathery feet, whose continuous motion creates currents in the direction of the shell, which

serve to carry the necessary nutritive particles to the mouth.

As we find it in its adult condition the barnacle is a much altered or metamorphosed animal, wholly unlike what it was before it became attached. In its earlier stage it is a free-swimming, active creature, with well-developed legs and a hinged bivalve shell, on the whole much like some of our so-called fresh-water fleas (*Cypris*). But it soon fixes itself by means of suckers developed upon the first pair of antennæ, exudes a slimy substance which helps to make the stalk, and thus, head downward, passes through those subsequent metamorphoses which lead up to the mature animal and almost completely mask its true character. Indeed, until within a comparatively few years the barnacles were classed with the mollusks, even the great Cuvier mistaking their affinities.

It might naturally be supposed that an animal so tightly closed up in its shell as is the barnacle would have little use for organs of vision, and that accordingly these organs would be found wanting. But careful investigation of the tissues has revealed the presence of a single eye-speck, of a duplex origin, not far from the region of the mouth, which, though thus deeply hidden within the shell, still permits the animal to distinguish at least between light and darkness. Allow your hand to pass over a pan of sea-water containing barnacles, and observe by their actions how readily the animals distinguish between the different intensities of light.

Several species of stalked-barnacles are found on

our coast, the two commoner being *Lepas anatifera*, in which the stalks grow to a length of from four to six inches, and *Lepas fascicularis*, in which, as the name indicates, a considerable number of individuals are closely bunched together or fasciculated. The former species, found on the bottoms of ships, is probably not indigenous to the region. It is an erroneous notion, which



LEPAS FASCICULARIS.

is shared by many, that the barnacles in any way injure the holds of vessels to which they may be attached. They merely impede navigation through the resistance which their enormous numbers offer to the water, and hence the necessity of keeping vessels clear of their colonies. An effective method of removal, frequently practised by sailing-masters, is to drive a barnacled vessel into fresh water, where the animals soon die and drop off.

Belonging to the same order of animals as the barnacles proper are the acorn-shells, those crater-like eminences that are found so abundantly encrusting rocks at about high-water mark, and scarcely less abundantly on the surfaces of shells, drift-wood, etc. They have the same general structure as the goose barnacle, but are devoid of the stalk or peduncle, and are hence known as 'sessile' barnacles. Where attached to a rock they leave a peculiar circular stamp of lime, which is not infrequently taken for a coral impression.



ACORN-SHELL (*Balanus balanoides*).

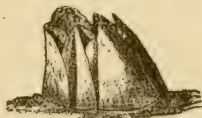
The shell of the acorn is usually conical in out-

line, made up of six plates in its circumference, and with a lid of four plates covering over the central orifice. The feathery appendages of the animal are thrust out from the top of the shell, instead of from the side, as we found it in the goose barnacle.

Our commonest species is *Balanus balanoides*, an exceedingly variable form, which makes dense crusts on rock-masses, piles, etc. In the typical variety the acorns or cups are comparatively low and broad, but in the more aberrant forms they are greatly elongated and more nearly tubular in appearance. A much larger species is *Balanus eburneus*.



BALANUS BALANOIDES.



BALANUS EBURNEUS.

neus, the 'ivory barnacle,' which can be readily distinguished from the preceding by its smooth broad form and its shelly base. It is abundant on all kinds of floating or submerged timbers, and not rarely accompanies the shells of various Crustacea. Much less frequently seen about our coast is the coronated acorn (*Coronula diadema*), whose seat of habitation is the skin of the whale, with which animal it performs long journeys over the sea.

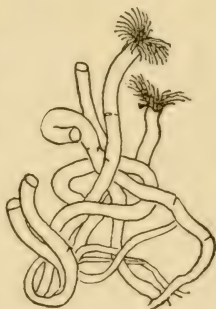
V.

WORMS, MOSS-POLYPS, SPONGES, ETC.

WORMS are in a general way not very attractive animals, yet they present much that is at the same time interesting and beautiful. This is particularly the case with the marine forms, whose burrows can be traced almost everywhere over the expanse of tidal flats which the retreating waters leave behind them. At these times the animals remain well within their habitations, from which they can be readily extracted through the use of a long-bladed garden-trowel. The many-footed *Nereis*, whose superb iridescence rivals in metallic effect the lustre of the tropical beetles, is of a type of beauty that is distinctively its own; and the same may be said of the medusa-like *Cirratulus* (Pl. 8, Fig. 6), of the green *Euchone*, or of the gordian *Amphitrite* (Plate 8, Fig. 1), with its crown of flesh-colored tentacles and blood-red gills. Some of these forms, like the *Serpulæ*, inhabit more or less permanently calcareous tubes of their own secretion; others, by exudation of a binding cement, construct their tubes of agglutinated sand-particles. Both of these types are known as tubicolous worms. To a third group, represented by the beautiful *Nereis* (Pl. 8, Fig. 9) and its allies (*Lumbriconereis*, Pl. 8, Fig. 3, and the brush-like *Eunice*),

the habit of frequently running about or sallying forth has given the name of the 'runners' (*Errantia*). The *Nereis* itself is a nocturnal animal, and sometimes appears in large numbers swimming about near the surface of the ocean.

All the forms that have here been noted have the body made up of a considerable number of rings or annuli, ranging to several hundred, which on either side give origin to two rows of spines or bristles, whence the term *Chætopoda*, 'bristle-footed,' as applied to the members of the group collectively. The crooked tubular habitations of *Serpula dianthus* can be seen on almost all objects that have drifted down to about low-water level—on old pots, pebbles, the under and lateral faces of rocks, surfaces of shells, etc. When disturbed or frightened, the animal withdraws itself into its tube, which it closes by means of a plug or operculum, and thus places itself in a position removed from its enemies. When extended it presents a beautiful appearance, with its distended crown of brilliantly-tinted branchiæ—red, yellow, purple, and brown—consisting of some thirty or more delicate feathery filaments. The brown sea-wrack occasionally brings to us, although less frequently than on the New England coast, small rounded bodies, not much larger than a pin's head, which to every appearance



SERPULÆ.

resemble flattened snails. They are the circular tubes of a worm, *Spirorbis*, whose relationship is immediately with the *Serpulæ*.

Of the group of worms in which the body is not distinctly annulated, known as false annelids, may be mentioned the earthworm-like *Sipunculus* (Pl. 8, Fig. 2), which can be easily recognized by its thick, fleshy, and irregularly constricted body, and by the long attenuated anterior extremity, designated the proboscis. It burrows in the sand and mud-bottoms, like the majority of the marine worms.

The free surface of the wide ocean, no less than the sheltered bays of the seaboard, harbors a very interesting worm-like animal, about an inch in length, and shaped somewhat like a lance, which disports itself in rather characteristic fashion, moving by rapid jerks through the water. It has long been familiar to naturalists as the *Sagitta*, or dart (Pl. 8, Fig. 5), but to this day nothing positive is known concerning its relationships. The body is white, translucent, and permits the alimentary canal to be distinctly seen in the interior. Laterally it is expanded into a sort of fin-like membrane, and a somewhat similar fin rounds off the tail region. Two dark pigment specks, the eyes, can be readily detected on the head.

MOSS-POLYPS.

Much of the sea-wrack that is drifted to our shores shows on its surface peculiar pitted incrustations which sometimes occur only in scattered patches, at other times in more or less continuous ramifications. The same structure can fre-

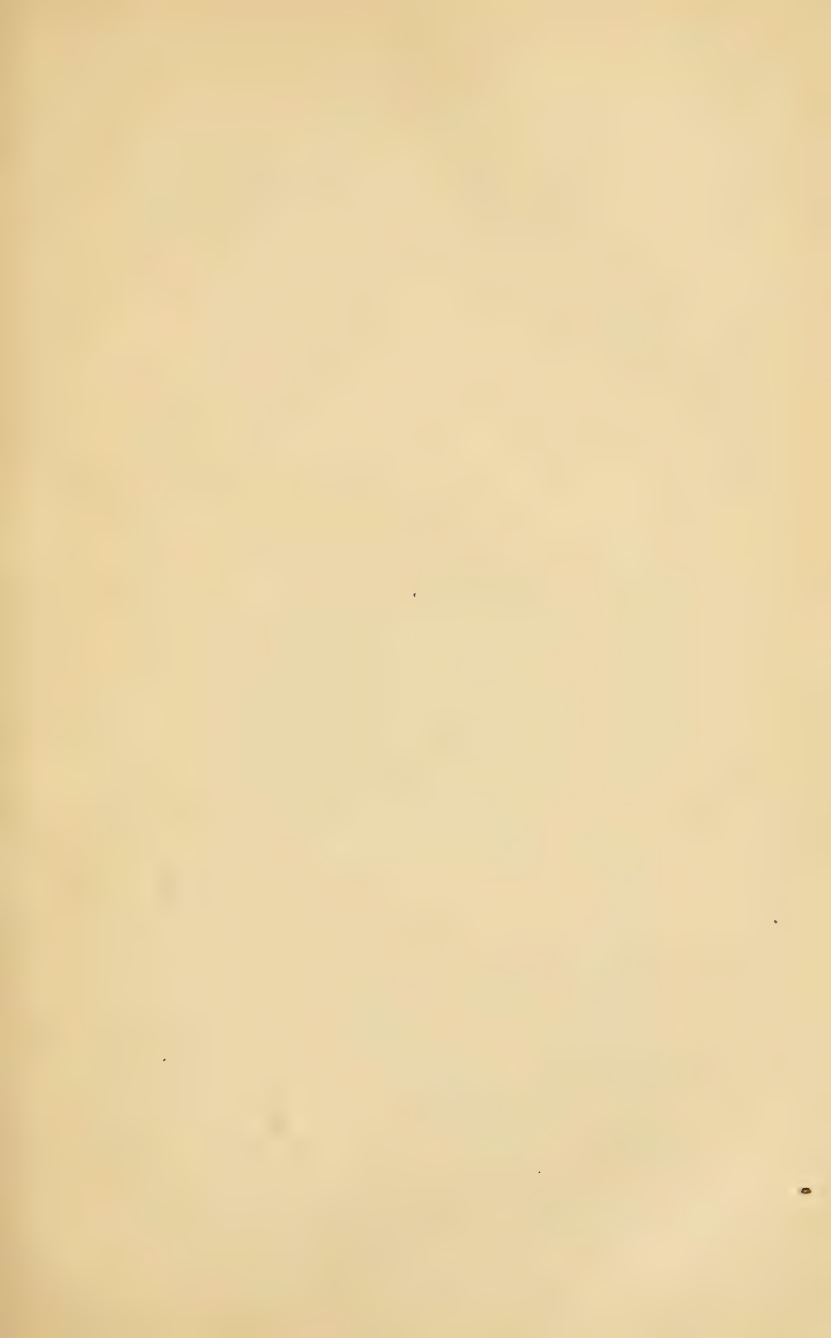
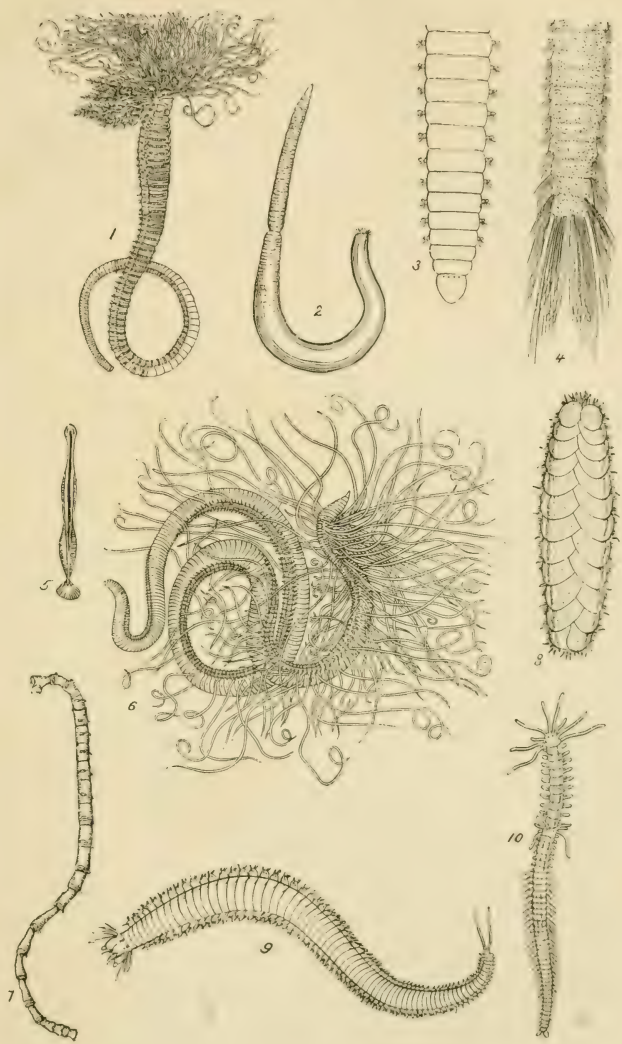


PLATE 8.

FIG.

1. *Amphitrite ornata*.
2. *Sipunculus Gouldii*.
3. *Lumbriconereis opalina*.
4. *Siphonostomum affine*.
5. *Sagitta elegans*.
6. *Cirratulus grandis*.
7. *Clymenella torquata*.
8. *Lepidonotus sublevis*.
9. *Nereis pelagica*.
10. *Autolytus cornutus*.



quently be seen on the insides of shells, around pebbles, over the tubes of the *serpula*, etc. From each of the tiny pits, which are often no larger than a pin-point, protruded during the life of the compound colony a minute polypide, delicately crowned with tentacles, in many ways reminding one of the polyps of the hydroid colonies with which we have already become acquainted. But these so-called moss-polyps or lace-corals—the *Polyzoa* of naturalists—show a considerable advance in structure over their hydroid brethren, inasmuch as they are provided with a distinct alimentary tract—stomach, intestine, etc.—clearly marked off from the rest of the body, a central nerve-mass, and other specialized organs which are wholly wanting in the other group. The mouth is situated at one side of, or within, the crown of tentacles, receiving its full complement of nourishment from the water-currents which are constantly being impelled towards it by the vibrating hairs (cilia) on the tentacles.

Perhaps the commonest of our encrusting forms is *Escharina*, whose delicate tracery can frequently be seen interwoven in concentric layers among or over the *serpula* tubes, making rounded masses from two to six inches across. In this condition they may be easily mistaken for pebbles, but their comparative lightness, and the numerous minute holes which become visible on closer examination, soon disclose their true character.



ESCHARINA
(magnified).

Other encrusting forms, but with the pores or cells arranged in only a single tier, are the ‘sea-



MEMBRANIPORA (magnified).



POLYPIDE (magnified).



ALCYONIDIUM.

mats,’ which are usually found on the fronds of the sea-weed. One of these (*Membranipora*) makes small scale-like patches, while another (*Flustra*) occurs in ramifying or spreading branches. A less readily recognizable form of polyzoan, the *Alcyonidium*, making fleshy crusts a third of an inch or more in thickness, is frequently found enveloping small stones, twigs, etc.

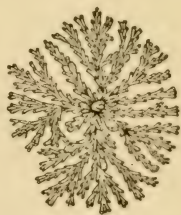


BUGULA.

While perhaps the most distinctive polyzoans are the ones which make crusts like those above described, others grow in erect, branching colonies, and thus still more closely resemble the swaying fronds of the true polyps. One of these is the common *Bugula*, whose tree-like forms, bearing tiny cups on their upright branches, strongly recall the serularians or sea-firs. They are of particular interest to the microscopist since they show to special ad-

vantage certain structures that are not present in all the members of the class. These are the 'bird-head processes' (avicularia), little snapping bodies of the general shape of a bird's head, which are found attached to the cells, but of whose real functions we as yet know very little. That they seize by a sort of instinctive movement little aquatic objects has been long since demonstrated, but the wherefore of this action still remains to be ascertained, since the particles thus caught cannot readily be turned to account by the animal. Other forms have in place of these avicularia long lashes or whips (vibracula), which are in almost constant motion, and may, at least in part, serve to keep the colony clean from adhering particles. The movement of both of these organs can be easily followed in the field of the microscope.

A beautiful rosette-formed polyzoon, *Crisia eburnea*, whose attachment is the frond of the sea-weed, is not rarely found scattered over the sands; it is easily distinguished, apart from its manner of growth, by the calcareous or limy character of its ivory-white habitations. Another white form (*Pedicellina Americana*), with minute club-shaped individuals, weaves a delicate tracery around the branches or stems of other polyp colonies, hydroids, etc.



CRISIA.

SPONGES.

Among the lowest forms of life that drift to our shores are sponges of one kind or another, many of them, doubtless, wafted northward on the current of the Gulf Stream, and then distributed by local storms. Some of these are of the horny character seen in the ordinary sponge of commerce, but usually they are of a much looser texture, and with a distinct disposition to branch. In the living condition of the animal this fibrous mass is enveloped in a soft jelly-like substance, frequently most brilliantly colored in tints of yellow, brown, and red, which constitutes the active or vitalized matter of the organism, the horny fibres themselves being merely an accessory in the way of an internal support or skeleton. The entire mass is then permeated by innumerable canals, into which the seawater gains access by a multitude of external pores, and from which it is expelled into a number of larger channels, into which the canalulæ open, and thence into the open sea again. A series of perpetual circulations is thus kept up within the substance of the animal, the cilia lining the channels helping along the water, and with it the microscopic food-particles that may be contained therein. The excurrent orifices (oscula) are of much larger size than the incurrent pores, and are frequently situated, crater-like, on special eminences. In our ordinary wash-sponges their positions are clearly indicated in the larger spaces left on the surface between the fibres.

There are few objects more interesting to watch than a sponge in action, but with us, unfortunately, the only native sponges of consequence are either thinly-branched or encrusting forms, which scarcely permit of observations being made upon their manner of living. One of these is the *Microscionia prolifera*, a rather scanty creeper on rocks and shells, having when fresh a bright red color. When full-grown it rises up into bunchy masses, measuring six inches or more across, which may be found scattered between the sedges of the sand where the latter has been left exposed at low-water. A much more delicate species, readily distinguished by its long and slender 'oculated' branches, is the *Chalina arbuscula*, whose habitat appears to extend along the greater part of the Atlantic coast.

The 'sea-bread' or 'sea-crackers,' rounded yellowish masses of an exceedingly light texture, which sometimes appear after a storm, are also skeletal parts of sponges, but their closely-packed and remarkably fine fibrous threads are composed principally of silica instead of horn, and thus approximate the type of the large and important group of silicious sponges, to which the 'glass rope' and 'Venus's flower-basket,' two of the most exquisite of nature's objects, also belong. The sea-bread (*Suberites*) has been dredged alive on the Massachusetts coast, and it has therefore been conjectured that its home must extend to that region.

Much more insignificant than the preceding is the form (*Cliona*) that attacks oyster- and clam-shells, burrowing into their midst from all direc-

tions, and soon reducing them to powder. Such sponge-bored shells and rock-fragments may be readily recognized by the numerous small holes that open upon the surface.

FORAMINIFERA.

Still lower in the scale of organization than the sponges are a number of animal forms whose existence is not very generally suspected by the visiting public. We walk leisurely over the sands, little suspecting that in so doing we may be ruthlessly crushing to powder thousands of minute shells that lie buried beneath our feet. To the ordinary observer the sand appears to be a mass of nearly homogeneous particles, little granules of white and black quartz, through which are scattered at intervals scales of mica, and exceedingly minute fragments of another mineral known as hornblende. These are all derived from the destruction of certain rock-masses—the granites and their allies principally—situated somewhere within the continental border, and merely accumulated by the sea after it has received the products of destruction from the various rivers discharging into it. But a more critical examination of the sand shows that in addition to the mineral substances above mentioned it contains at times—and it may be said, at almost all times—great quantities of tiny rounded shells whose dimensions barely exceed those of the sand-particles themselves. Without the aid of a magnifier these shells are almost undistinguishable; but the lens and a practised eye will soon pick out the

interesting mites whose life-history we are now prepared to read.

Placed in the field of a microscope, these shells exhibit on their surfaces innumerable punctæ or dots, which are in reality minute pores leading through the shell into the interior. Through these pores the animal substance that is contained within may be extended in the form of delicate processes, known as false feet (pseudopodia), by means of which the currents of food-particles may be directed to the organism. The bulk of the animal itself consists of a tiny bit of jelly-like substance, known as protoplasm, which shows none of the organs that are common to the higher animals; that is to say, there is neither mouth, stomach, heart, nor nerve. But despite these deficiencies the animal passes through the cycle of life with a free and satisfactory performance of the usual processes of assimilation, growth, and reproduction. There are few kinds of animals that are simpler in structure than these so-called pore-bearers (Foraminifera), and one of these is the almost universally distributed proteus-animalcule of our fresh waters (*Amœba*), which differs only in the absence of a shell.

The simplest form of foraminiferal shell is a hollow sphere, in which the protoplasm, or active animal substance, is lodged. In other forms this primitive sphere buds out into a number of additional spheres, which gradually increase in size from the oldest to the newest, and may develop either one in advance of the other in a straight

line, or, what is more usually the case, in one or more circles around the initial sphere. A complex arrangement of chambers may thus be built up, especially if the system of development has proceeded along more than a single plane. Of such a complex character is our little *Rotalia* of the ocean sands, the different chambers in the shell of which can be clearly traced out with the aid of the microscope.

The Foraminifera lead an apparently very independent life on the ocean wave, tossed hither and thither among the seething waters: their home is not merely the surface, but extends to the gloomier shades of the abyss. At the bottom of the sea the shells of the dead animals accumulate in prodigious numbers, forming there a deep white or gray mud known as the 'Atlantic ooze.' It is this same substance compacted which constitutes true chalk, and likewise much of the hard limestone and marble which we see everywhere about us. At one time the areas where we now find chalk and marble were beneath the sea, but through movements of the earth's crust of one kind or another they have been brought to their present inland positions. The so-called 'greensands' or 'marls' of New Jersey are largely a foraminiferal composition, the little green pellets of the mineral glauconite, which give the distinctive appearance to the sand, representing principally the fillings or casts of an endless number of foraminiferal shells, from which the lime has been removed through solution.

Some idea of the vast numbers in which these minute organisms occur may be gathered from the fact that an ounce of sand taken from the beach of Atlantic City, despite the breakages to which the minute shells were liable in being tossed and rubbed about, was estimated to contain fully 18,000 individuals of a single species of *Nonionina*, and that a similar measure taken from the sands of Cape May yielded by computation upwards of 38,000 individuals of the same species.

VI.

SOME COASTWISE FISHES.

AMONG the odds and ends that the incoming flood casts upon the beach are the peculiar pillow-shaped objects with long-drawn-out corners which are generally known under the name of 'sea-purses.' Great is the discussion attending the finding of one of these sea-purses, and many are the conjectures regarding their true nature. The specimens found on the sand are usually dry and split in the purse portion, showing nothing within ;



'SEA-PURSE.'

but when freshly drawn from the sea-weed to which they were at one time firmly attached, they contain each a solitary egg, or, if development has proceeded sufficiently far, an embryo in place of the egg. This embryo is the young of the skate or ray, that common representative of the shark tribe of fishes, whose broad fleshy masses, with a grinning mouth on the under surface, are

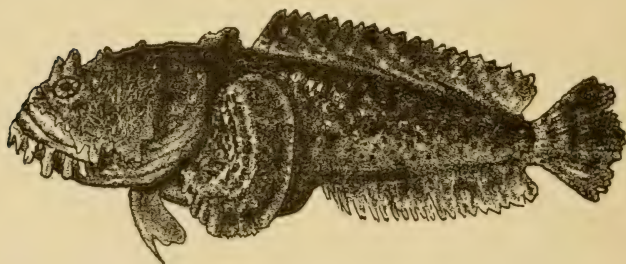
frequently exposed on our market-stalls. The purse, or 'shark-barrow,' as it is termed in England, is the egg-capsule of this singular creature, by whom it is deposited in the forest of sea-weed, to be there safely anchored by one or more of its filamentous processes.

The rays or skates (*Raia*) are not uncommon along our coast, where they occupy the bottom water, skimming about just over the sand or mud. Their flabby masses are occasionally stranded on the beach, where they are soon picked to pieces by the ever-watchful sea-fowl in search of such delicacies. Of the remaining cartilaginous skeleton, the jaws, whose small pavement-like teeth eminently serve the purposes of grinding, generally remain the longest, and are often found still attached to each other when nothing else remains.

Somewhat similar jaws, but with the teeth sharp and pointed, instead of flat and pavement-like as in the rays, are the belongings of true sharks, several species of which wander about our shores. The commonest of these is the sand-shark or shovel-nose (*Carcharias Americanus*), an exceedingly voracious animal, measuring when full grown some six or seven feet. The teeth are sharp and awl-like, whence the name *Odontaspis* applied to the genus by many naturalists. In the majority of the sharks the teeth are disposed in several distinct series, but only those of the outer row are functional at any one time. When these are lost they are immediately replaced by the teeth of the second series, which, as well as the remaining teeth, are articu-

lated to the jaw in such a manner as to permit of their erection when necessary. In this manner the different series are successively brought into play.

It is impossible in the scope of a work of this kind to enter into anything like a general description of the New Jersey coast fishes, since their history is largely the history of the fishes of the entire Atlantic border. But reference to a few of the more striking forms—such, more particularly, as by their peculiar outlines are apt to attract attention—may not be amiss in this place. One of these is the toad-fish (*Batrachus tau*), a rather fierce

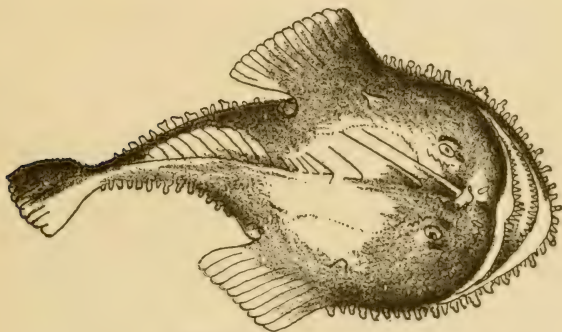


TOAD-FISH.

and repulsive-looking animal, having somewhat the appearance of a toad, whence its name. The determination with which it holds on to any object that it may have seized has given to it the name of 'sea bull-dog.' It inhabits largely the oyster-beds, where the young make free use of the empty shells for their domiciles.

The fishing-frog (*Lophius piscatorius*), also so called from its resemblance to a batrachian, but

representing a family very distinct from that of the toad-fish, is certainly one of the most interesting of the coast-fishes. Its greatly expanded body and head, with broad transverse mouth—whence the names ‘kettle-maw,’ ‘wide-gut,’ ‘all-mouth,’ etc.—and the peculiar ‘angling’ appendages rising from the back, impart to the animal an individuality which is, to say the least, striking. It was the supposition of the earlier naturalists—a supposition, doubtless, resting chiefly upon a fable that



FISHING-FROG (ANGLER).

had been handed down from antiquity—that the purpose of the foremost of the filiform appendages on the back was the securing of food, the fish being actually credited with a knowledge of the art of angling. Hence to this day it is still commonly known as the ‘angler.’ But there can be little doubt that these peculiar whips, as well as the various other membranous appendages that belong to the body, and the coloring of the surface, are

part of a scheme of general deception by which the animal succeeds in making itself almost undistinguishable among the rocks and grasses which it inhabits.

The angler is an exceptionally voracious fish, its ungovernable appetite being well ministered to by a superabundance of mouth and stomach. It is stated on authority that seven wild ducks have been taken from the stomach of a single one of these animals. The eggs are deposited in a long floating gelatinous ribbon measuring some thirty feet or more in length, and weighing, it is said, as much as forty pounds.

The 'moon-fishes' (*Selene*) and 'dollar-fishes' (*Vomer*), which can be recognized by their rounded and greatly compressed upright bodies, are interesting little animals, much appreciated for their brilliant sheen.

There are a number of long-beaked fishes found on the coast, one or more of which can generally be picked up in the grass-covered shoals that extend along a part of the shore. Among the better-known of these are the pipe-fishes (*Siphostoma*) and sea-horses (*Hippocampus*), which differ principally from one another in the shape of the body, the former being greatly elongated, while the latter is gracefully flexed or coiled, the head and anterior part of the body recalling the knight of the chess-board. The males of both species are provided with peculiar pouches placed on the under surface of the body, in which the eggs, deposited there by

the female, are cared for. The pipe-fishes are rather slow in their movements, and can be readily picked up by the hand or net; they are frequently stranded.

Of comparative rarity with us, although more abundant in the southern waters, is the tobacco-pipe fish (*Fistularia tabaccaria*), which can be immediately distinguished from the pipe-fish proper by its generally flexible body, its greatly elongated beak, and the singular lash-like tail.

A widely differing form, but yet characterized by a prominent beak, is the half-bill (Hemiramphus), so called from the unequal development of the two jaws, the lower one alone being specially elongated. Here also belong the gar-fishes or thread-fishes (*Belone*).

The two remaining forms with which we close our sketch of some of the more striking of the New Jersey coast fishes



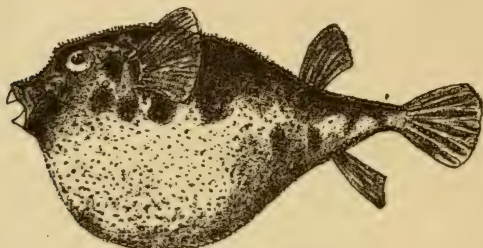
SEA-HORSE.



PIPE-FISH.

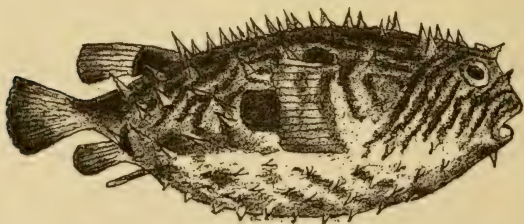
are known as puffers, from the habit they have of inflating their bodies by rapid inspirations, whether of air or of water. The swell-toad or egg-fish

(*Tetrodon turgidus*) is an interesting little animal, very common on some parts of the Atlantic coast. When hauled from the water it immediately inflates itself, and sometimes several inflations, ac-



SWELL-TOAD (PUFFER).

panied by as many collapses, will follow one another in rapid succession. This procedure is especially noticeable when the animal is irritated. Of much larger dimensions, and strongly armed



ZEBRA-FISH (RABBIT-FISH).

with spines, are the porcupine-fishes (*Diodon*) and the rabbit-fishes (*Chilomycterus*), the latter beautifully ornamented with regular wavy lines and spots of a dark color.

INDEX.

Acorn-shell, 106.
Actinia, 69.
Alcyonidium, 112.
Amorcecium, 58.
Amphitrite, 108.
Angler, 123.
Anomia, 47.
Arbacia, 77.
Argonaut, 15.
Ark-shell, 50.
Asterias, 73.
Astrangia, 72.
Auger-shell, 29.
Aurelia, 66.

Balanus, 106.
Barnacles, 102.
Batrachus, 122.
Beach-flea, 95.
Belone, 125.
Birgo, 85.
Boltenia, 56.
Bopyrus, 96.
Botryllus, 57.
Brittle-stars, 75.
Buccinum, 20.
Bugula, 112.

Calamary, 9.
Callinectes, 85.
Campanularia, 62.
Cancer, 85.

Caprella, 96.
Carcharias, 121.
Caudina, 80.
Cerianthus, 71.
Chalina, 115.
Chilomycterus, 126.
Cirratulus, 108.
Clam, 32.
Cliona, 115.
Corals, 71.
Coronula, 107.
Crabs, 81.
Crangon, 94.
Crepidula, 30.
Crisia, 113.
Crucible-shell, 32.
Ctenophora, 67.
Cuttle-fishes, 8.
Cyanea, 65.
Cynthia, 56.

Dactylometra, 64.
Diodon, 126.
Diplothyra, 40.
Dog-whelk, 21.
Dollar-fish, 124.
Donax, 44.
Drill, 30.

Echinarachnius, 75.
Egg-fish, 125.
Escharina, 111.

Euchone, 108.
 Eunice, 108.
 Eupagurus, 92.

Feather-stars, 75.
 Fiddler-crab, 81.
 Fishes, 120.
 Fishing-frog, 122.
 Fistularia, 125.
 Flustra, 112.
 Foraminifera, 116.
 Fulgur, 17.

Gammarus, 96.
 Gebia, 93.
 Gelasimus, 84.
 Goose barnacles, 104.

Halcampa, 71.
 Half-bill, 125.
 Hemiramphus, 125.
 Hermit-crabs, 89.
 Hippa, 95.
 Hippocampus, 124.
 Hoppers, 95.
 Horse-muscle, 52.
 Horseshoe crab, 99.
 Hydractinia, 24.

Idotea, 97.

Jelly-fishes, 63.

King-crab, 99.

Lace-corals, 111.
 Lepas, 106.
 Limnoria, 97.
 Limulus, 101.
 Littorina, 24.

Lobster, 93.
 Loligo, 9.
 Lophius, 122.
 Lumbriconereis, 108.

Mactra, 34.
 Medusæ, 63.
 Megalops, 86.
 Melampus, 31.
 Mellita, 77.
 Membranipora, 112.
 Metridium, 70.
 Microscionia, 115.
 Modiola, 52.
 Mole-crab, 95.
 Molgula, 55.
 Moon-fish, 124.
 Moss-polyps, 110.
 Muscle, 51.
 Mya, 36.
 Mysis, 94.
 Mytilus, 51.

Nassa, 21.
 Natica, 27.
 Nautilus, 14.
 Nereis, 108.
 Nonionina, 119.
 Nucula, 50.

Obelia, 62.
 Ocypoda, 87.
 Ommastrephes, 12.
 Ophiura, 75.
 Opossum-shrimp, 94.
 Orchestia, 95.
 Oyster, 45.

Palæmon, 94.
 Pandora, 44.

- Panopeus, 88.
 Parypha, 62.
 Pear-conch, 17.
 Pecten, 48.
 Pedicellina, 113.
 Pennaria, 60.
 Periwinkle, 24.
 Petricola, 37.
 Pholas, 39.
 Physalia, 66.
 Pinnotheres, 88.
 Pipe-fish, 124.
 Platyonichus, 85.
 Pleurobrachia, 67.
 Polyps, 58.
 Porcupine-fish, 126.
 Porpita, 66.
 Portuguese man-of-war, 66.
 Prawns, 93.
 Psolus, 79.
 Puffer, 125.
 Purple, 30.
 Purpura, 30.
 Pycnogonoids, 102.

 Quahog, 35.

 Rabbit-fish, 126.
 Ray, 120.
 Razor-fish, 42.
 Rotalia, 118.

 Sagartia, 71.
 Sagitta, 110.
 Sand-clam, 36.
 Sand-dollar, 75.
 Sand-flea, 95.
 Saxicava, 42.
 Scalaria, 30.
 Scallop, 48.

 Sea-anemones, 68.
 Sea-bread, 115.
 Sea-cracker, 115.
 Sea-cucumbers, 78.
 Sea-eggs, 75.
 Sea-fir, 59.
 Sea-horse, 124.
 Sea-peach, 56.
 Sea-pear, 56.
 Sea-pork, 57.
 Sea-purses, 120.
 Sea-spider, 88, 102.
 Sea-urchins, 75.
 Selene, 124.
 Sepiola, 13.
 Serpula, 109.
 Sertularia, 59.
 Sesarme, 87.
 Sharks, 121.
 Ship-worm, 40.
 Shrimps, 93.
 Siphostoma, 124.
 Sipunculus, 110.
 Skate, 120.
 Slipper-limpet, 30.
 Solecurtus, 44.
 Solen, 42.
 Spirorbis, 110.
 Spirula, 14.
 Sponges, 114.
 Squid, 9.
 Squill, 97.
 Squirts, 55.
 Star-fishes, 73.
 Stenosoma, 97.
 Strongylocentrotus, 77.
 Suberites, 115.
 Surf-clam, 34.
 Swell-toad, 125.
 Synapta, 78.

Talorchestia, 96.
Tellina, 44.
Terebra, 29.
Teredo, 40.
Tetrodon, 126.
Thread-fish, 125.
Toad-fish, 122.
Tobacco-pipe fish, 125.
Tubularia, 61.
Tunicates, 55.

Urosalpinx, 30.

Velella, 66.

Venus, 34.
Vomer, 124.

Wedge-shell, 44.
Wentletrap, 30.
Whelk, 20.
Worms, 108.

Xylotrya, 42.

Yoldia, 50.

Zebra-fish, 126.
Zoea, 86.

THE END.

BY THE AUTHOR OF THIS VOLUME.

TOWN GEOLOGY:

THE LESSON OF THE PHILADELPHIA ROCKS.

STUDIES OF NATURE ALONG THE HIGHWAYS AND AMONG THE
BYWAYS OF A METROPOLITAN TOWN.

8vo. Cloth. With Illustrations of the Fossils of the Marls, Sketches
of Scenery, Diagrams, and Geological Maps.

Price, \$2.00.

THE above work is intended as an introduction to the study of nature, using for its text the rocks and stones of the neighborhood of Philadelphia, on both sides of the Delaware. It leads the reader by a series of excursions to points of special interest in connection with geological inquiry, and directs him how to observe, and what to observe.

"Professor Heilprin's explanations of principles are so clear, and his methods of investigation so admirable, that a careful perusal of his book ought to give the would-be student all the cues he may need for an intelligent study of the geology of his neighborhood, no matter where it may be."—*Philadelphia Evening Telegraph*.

"His delightful book subordinates the dry scientific to the picturesque and poetic. There is no gentleman or lady dwelling anywhere near Philadelphia, on either side of the Delaware, who, if endowed with any taste for the work of creation, will not enjoy this curious monograph."—*Philadelphia Evening Bulletin*.

"Professor Heilprin adopts that happy style of presenting the scientific facts with which he is familiar which Hugh Miller and Huxley and Tyndall, and many others, have done much to associate both with sound and with unsound science."—*Journal Franklin Institute*.

"The present volume is an admirable exemplification of the true method of geological study. . . . The work is admirably done, and the studious citizens of the Quaker metropolis owe their best thanks to the young geologist who has performed the task."—*Popular Science Monthly*.

Will be sent, post-paid, on receipt of price by

J. B. LIPPINCOTT COMPANY,

715 and 717 Market Street, Philadelphia, Pa.

BY THE AUTHOR OF THIS VOLUME.

1888.

THE GEOLOGICAL EVIDENCES OF EVOLUTION.

A POPULAR EXPOSITION OF FACTS BEARING UPON THE
DARWINIAN THEORY.

By ANGELO HEILPRIN,

Professor of Invertebrate Paleontology at, and Curator-in-Charge of, the
Academy of Natural Sciences of Philadelphia.

Author of "Town Geology: The Lesson of the Philadelphia Rocks,"
"The Geographical and Geological Distribution of Animals"
(International Scientific Series), etc.

12mo. Cloth. Fully Illustrated. Price, \$1.00.

"The preacher or layman who desires to know something of the facts, and something of the kinds of facts which recommend themselves to the naturalist in considering such questions, will do well to read this little book."—*New York Nation*.

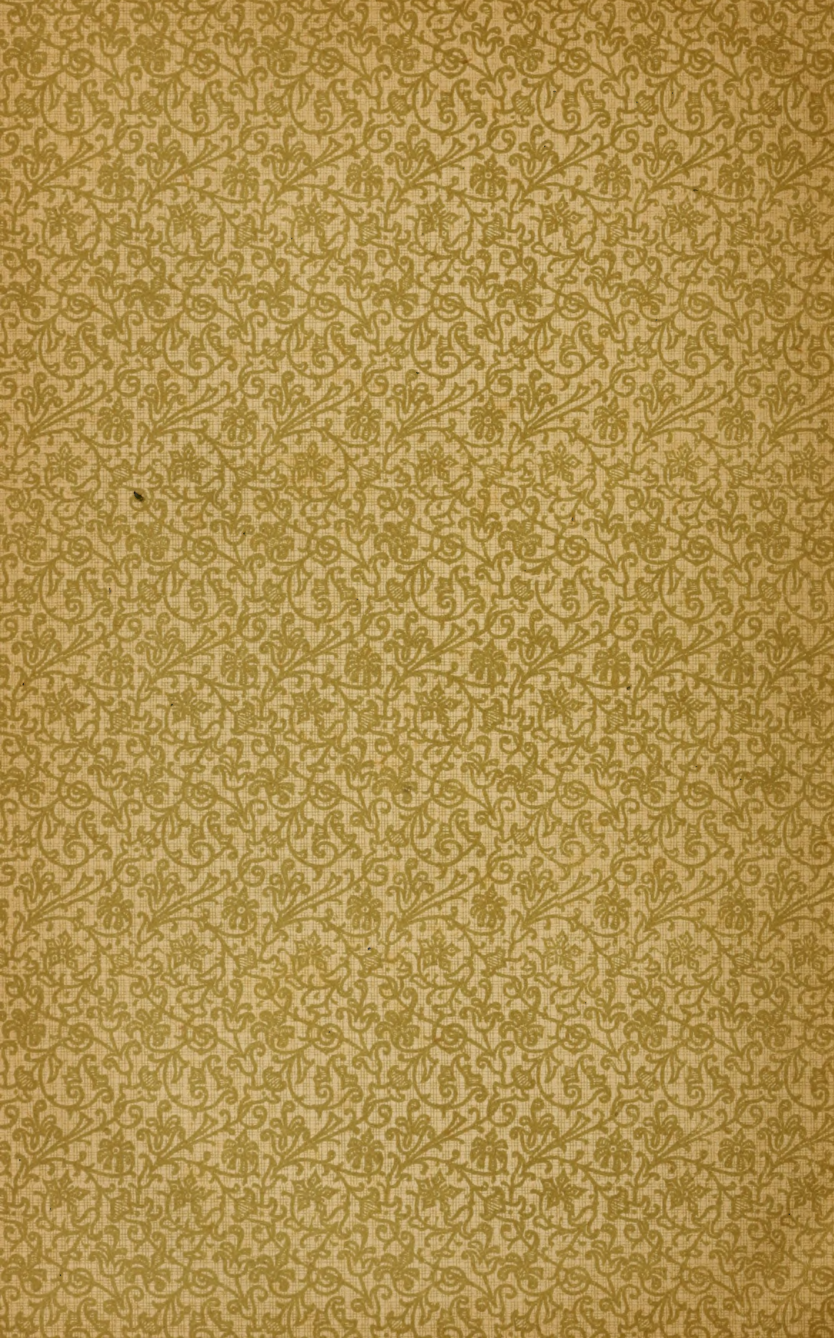
"The reader who wishes to have his conceptions clearly up and made definite on this subject can find nothing better here or abroad than Professor Angelo Heilprin's 'Geological Evidences of Evolution.'"—*Book News*.

Will be sent, post-paid, on receipt of price by

J. B. LIPPINCOTT COMPANY,

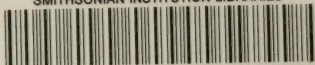
715 and 717 Market Street, Philadelphia, Pa.







SMITHSONIAN INSTITUTION LIBRARIES



3 9088 00718 7578